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A TACTICAL DATA SIMULATION PROGRAM FOR THE CONTROL DATA 1604 COMPUTER AND THE dd65 DISPLAY CONSOLE

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and
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and

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by

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Lieutenant, United States Navy

and

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Submitted in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE
IN
ENGINEERING ELECTRONICS

United States Naval Postgraduate School

Monterey, California

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U. S. Naval Postgraduate School
Monterey, California

ABSTRACT

There exists a need for a simulation program that will enable a programmer to simulate systems such as the Naval Tactical Data System (NTDS), Marine Corps Tactical Data System (MTDS), Airborne Tactical Data System (ATDS), or any other system that uses radar or sonar information for operation. A programming project was undertaken using the Control Data 1604 Computer (CDC 1604) and the Data Display Incorporated model dd65 Display Console (DD65) as the basic hardware. The program developed features on-line control of the CDC 1604 by the DD65, display of simulated targets and messages on the DD65, control of tracks by operating personnel from the DD65, continuous graph output for permanent record purposes, and real time or double real time operation. This program can be expanded to provide more features of any of the tactical data systems by the addition of the appropriate subroutines.

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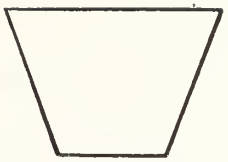
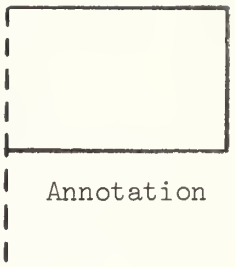
TABLE OF SYMBOLS

Basic Symbols



Input/Output

Processing



Annotation

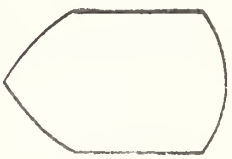
Specialized Input/Output Symbols

Punched Card

Document

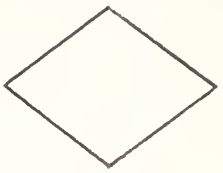
Manual Input

Display

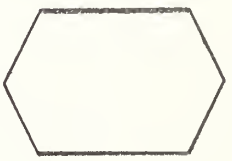


Specialized Processing Symbols

Decision



Predefined Process



Additional Symbols

Entry/Exit

Connector

Statement Tag

Off-page connector

1. Introduction.

1.1 Background. With the development of new weapons systems, there has been a renewed interest in the study of tactical methods and the importance of command decisions. This first manifested itself in studies of abstract mathematical models which later provided the basis for pure computer simulation. By a thorough analysis of the results of the simulation, much valuable data on expected system performance was obtained; however, these models did not allow for the man made command decision, nor did they operate in real time with a realistic environment. There must be a more flexible man-machine interface to allow the tactician to construct controlled situations at will, to observe directly the effect of one or more command decision links, to modify parameters assumed for system components, and to provide hard-copy records for a later critique of the situation.

1.2 Proposed Approach. The objective of the thesis project to be described in this paper was to undertake, within the constraints of currently available equipment, the implementation of a simulation system that would be used as a test vehicle to study any problem that involve trajectories. The salient characteristics of the system were to be:

(1) A flexible, fine grain, three dimensional track generator.

(2) A direct man-computer interaction capability (i.e. "on-line" control).

(3) A language independent approach to setting up simulated tactical situations.

(4) A modular approach to inserting sub-systems for testing.

(5) A real time approach to the simulation problem.

A flexible track generator was felt to be a basic necessity in order to provide realistic problem inputs to replace the classical step and ramp input functions. The track generator should have the capability of duplicating the actual position information available to a surveillance system.

In order to take maximum advantage of man-computer interaction capability, it was felt there was a need for direct man-computer communication as well as pre-programmed communication. To this end, an executive routine, that would act as the coordinating routine between the track generator, man communication, display, etc., would be developed. The executive routine would operate in real time in order to provide realistic simulation.

1.3 User Capabilities.

1.3.1 Tactical Data Simulator. A typical tactical data problem (NTDS type) would be one of pre-programmed hostile tracks, one or more surface ships on station, and one or more friendly aircraft, each under computer (pre-programmed) or console control. Then either a canned problem or an actual problem could be run using the console for track modification.

By use of the hard-copy critique output, the user may examine one or more of the following:

(1) The quality of the position information generated by his systems equations.

(2) The effects of various noise environments upon the quality of position information.

(3) The results of tactical decisions made and a comparison of the results, of rerunning the problem, with different tactical decisions being made.

1.3.2 Control System Test Vehicle. An example of a control system test vehicle would be a test of a Carrier Automatic Landing System. The track generator would furnish the fine grain aircraft position data and would receive orders from the landing system computers. The stability of the Carrier Automatic Landing System, as well as its accuracy, versus changing parameters could readily be studied. Using the same approach, many different types of control systems could be studied, such as:

(1) Air to Surface missile systems.

(2) Surface to Surface missile systems.

(3) Surface to Air missile systems.

(4) Subsurface to Air missile systems.

2. Programming.

2.1 Programming Language. The following languages were readily available to the authors:

(1) FORTRAN 60.

(2) FORTRAN SYMBOLIC.

(3) FORTRAN 63.

(4) ALGOL.

(5) SCRAP.

(6) CODAP.

In choosing a language, several criteria must be met:

(1) Ease of manipulating individual bits.

(2) Flexible input/output routines.

(3) Availability of diversified library subroutines.

(4) Flexibility of operation.

(5) Ease of programming.

Some of the available languages satisfied several of the desired criteria, however, it was felt that only FORTRAN SYMBOLIC met all of the requirements. In addition, the FORTBIN compiler associated with FORTRAN SYMBOLIC is very reliable and libraries may be manipulated at will. For these reasons FORTRAN SYMBOLIC was chosen.

2.2 Initial Programming. Initially, it was decided to divide the programming into two areas. These areas were:

(1) Executive Control Routine.

(2) Track Generator.

It was felt that each of these areas were independent enough to allow for separate work. A general outline of the interface was set down,

	EXECUTIVE FLAG TABLE (EFT)	EXECUTIVE TIME TABLE (ETT)	EXECUTIVE JUMP TABLE (EJT)
1		1 second	A
2		6 seconds	B
3		6 seconds	C
4		10 minutes	D
5		2 hours	A
6		1 minute	E
7		30 seconds	F
8		4 seconds	H
9		1 hour	D
M =10			

Figure 1. Example of Executive Table Structure

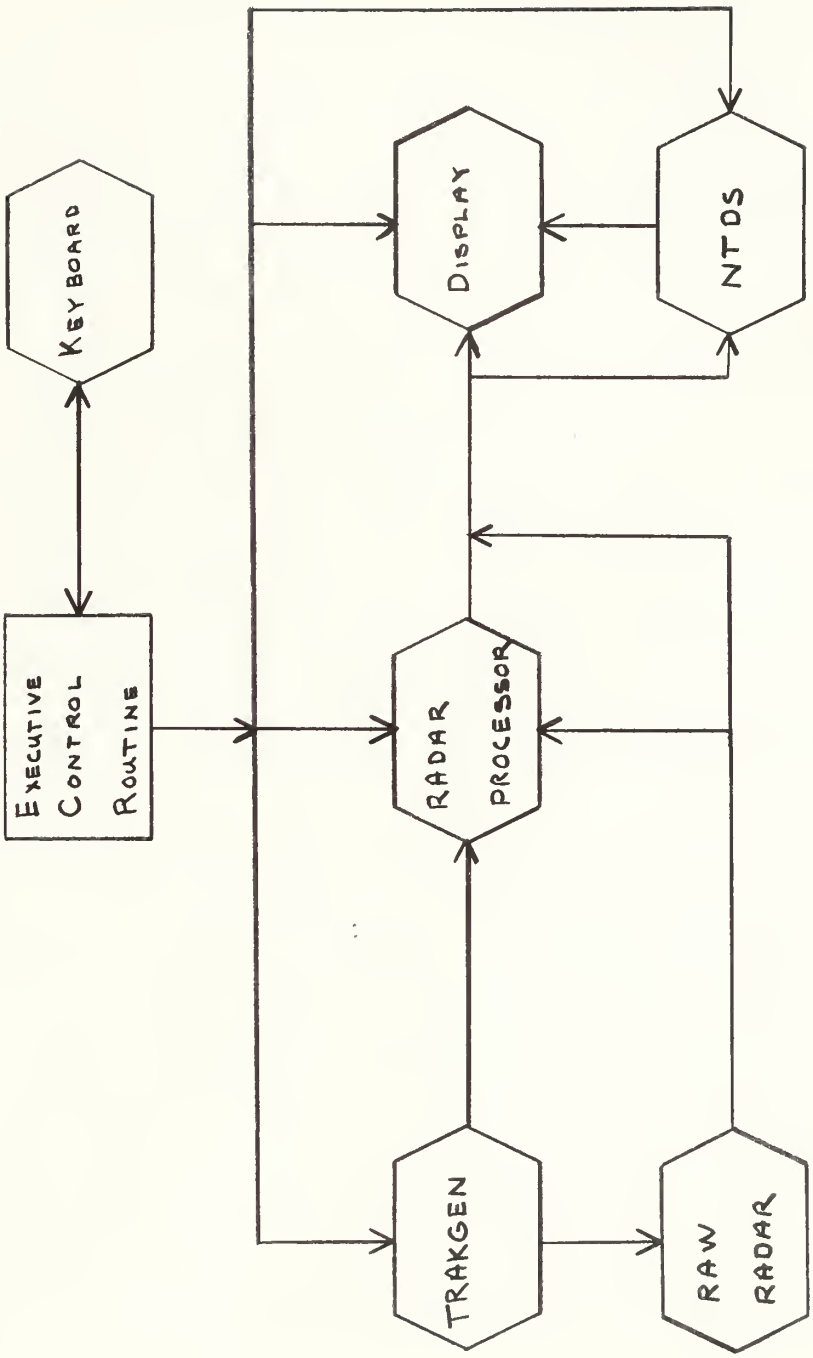


Figure 2. Original Concept of SIMONE

with the final details left to be established as the programs developed. This worked very satisfactorily.

2.2.1 SIMONE.

2.2.1.1. Basic Philosophy. Upon analysis of the problem, the initial frame work was set down as represented by Fig. 2. The system was to operate in real-time, therefore, an executive routine would be needed and would be the heart of the system. The philosophy of the executive routine is found in [14]. Briefly this philosophy is:

(1) Subprograms are considered for execution on the basis of their priorities as system components.

(2) Subprograms would be listed by priority and this list would be scanned sequentially, executing subprograms as they are needed.

(3) After each execution, the scanning process would be resumed starting with the highest priority entry.

(4) Assumption is made that sufficient computational capability exists to perform all assigned tasks.

(5) A subprogram is executed only when its "flag" is set.

The executive control philosophy is implemented through a method of table control. Three tables, Executive Flag Table (EFT), Executive Time Table (ETT), and Executive Jump Table (EJT), contain the necessary information for executive control. See Fig. 1. There is a one-to-one correspondence between these tables. Fig. 3 is a flow chart of the Executive Control Program. Starting with this basic routine and the functions of the following subprograms, the initial programming was undertaken:

(1) Keyboard Processor

(2) Radar Processor

(3) Track Generator

(4) Display Routine

(5) Raw Data Routine

(6) NTDS Routine

2.2.1.2 Programming and Problems. The implementation of Fig. 3 was accomplished with very little difficulty. The executive tables were implemented as arrays with the exception of the EJT. The EJT was programmed as the addresses of jump instructions in the program. By using the philosophy of the computed GO TO of FORTRAN, the appropriate jump will be executed based on the EFT index.

With the basic control routine working, the next step was to determine the method by which the DD 65 would communicate with the main computer. There are two basic methods by which the DD 65 may communicate with the CDC 1604. The first is via the CDC 160 and the second is via Channel 7. The first method involves the use to the CDC 160 to interrogate the DD 65 and then to transfer the information from the DD 65 to a buffer in the CDC 160 and then finally to transfer this stored information to the CDC 1604. This method is similar to that used in satellite operations. [12] The second method provides for direct communications between the CDC 1604 and the DD 65 via Channel 7. The latter method has two modes of operations with respect to the DD 65, active and passive. The active mode involves the use of the interrupt features of the DD 65 while the passive mode involves an interrogation similar to that used by the CDC 160. The first method using the CDC 160 was not

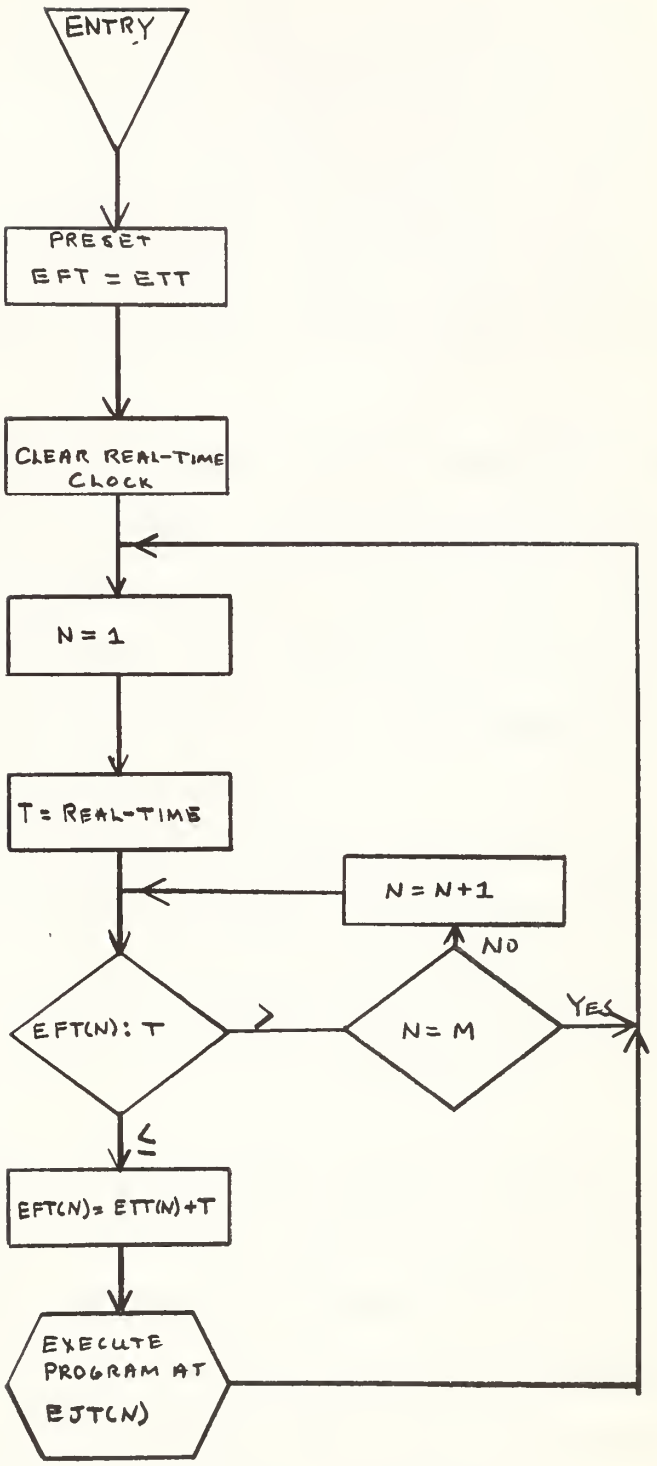


Figure 3. An Executive Control Program

chosen due to the desire to keep the programming as simple as possible. The active mode of the second method was chosen because of its ability to provide continuous control of the CDC 1604. In the passive mode, control of the CDC 1604 would occur only at predetermined times. This may or may not be desirable. In the active mode, the desired control information is transferred to the CDC 1604 instantaneously. This instantaneous transfer allows for the fastest response to the commands originated at the DD 65 console. With these decisions made, the major programming was started.

To program the interrupts, a copy of the MACHINE RESIDENT was used to determine the actual address in memory of the clock processor. By substituting the address of SIMONE's interrupt routine in lower cell 7, and by jumping to the clock processor after checking for interrupts from the DD 65, the interrupt tests were ready to run. This arrangement proved to be satisfactory for the time being.

As the program developed, changes were made to RESIDENT and consequently the program had to change. In order to make SIMONE independent of any address in RESIDENT, the clock processor was incorporated in SIMONE's interrupt processing routine. At this time the double real-time feature was also added.

The next problem was that of how to handle the input functions. The first approach was to use a very complicated jump table and flags within the subroutines. This approach proved very cumbersome, therefore, a new solution was sought. This solution came in the form of a 30 x 3 matrix, which composed a control table for Keyboard 2, and a buffer for storage of both Keyboard 1 and 2 information. See Fig. 5 for Keyboard 2

Control Table. Each row in the matrix corresponds to one of the switches on Keyboard 2. The columns provide information that enables the computer to process the command.

The problem of display was solved with the development of subroutine PRINT. For a complete explanation see Appendix III. For the display, symbols had to be developed by using the vector mode of the DD 65. These symbols are shown in Fig. 6. The results were not entirely satisfactory. The raw radar symbol was changed to just two vectors end to end with the X and Y position located at the junction of the two vectors. The remaining symbols are fine for the smaller scales, however, they are too large when the display scale is set for 256 miles. These symbols are, however, the smallest available with present equipment and logic.

As the philosophy of the program expanded, it became evident that there must be some type of hard-copy record of each problem run. This was the beginning of the critique routine. The initial thoughts centered around the use of scratch tapes to have all information and then at the end of the problem to provide a graph output. The basic idea was to plot one graph that would show all tracks in the xy plane. The critique routine was programmed and tested. The results of the test showed this method to be feasible, however, some difficulty was encountered. When trying to read the scratch tape, parity errors occurred. To eliminate this problem, memory was chosen to be the scratch pad. This proved quite satisfactory, however, due to the limited size of the scratch pad, only 10 minutes of information could be stored. The solution to this problem was another subprogram that would plot a

graph every 10 minutes. During the reprogramming, a second graph was added that would provide for an altitude profile vs. time plot. The last modification included the point plotting of both the smoothed position and the actual position at time intervals to be specified by the user.

The radar processor was made very simple. It included the smoothing equations normally associated with the "Alpha-Beta" tracker. [1]. It is in this routine where there is much to be done. Several types of smoothing and predicting equations are available. Both the NTDS and the MTDS systems were studied.

As the programming continued, the basic frame work was expanded to include many routines. These routines are explained in detail in Appendix I and an explanation of their use is found in Section 4.4.2. See Fig. 4 for final Block Diagram.

2.2.1.3 Future Expansions. There are many areas for expansion. Some of these would be:

(1) On-line graph plotting on an XY plotter.

(2) New smoothing equations.

(3) A more complete intercept routine.

(4) A more sophisticated display routine.

(5) Integration of program with FORTSHARE [12] .

(6) Incorporation of a radar characteristic table.

(7) A more complete aircraft characteristic table.

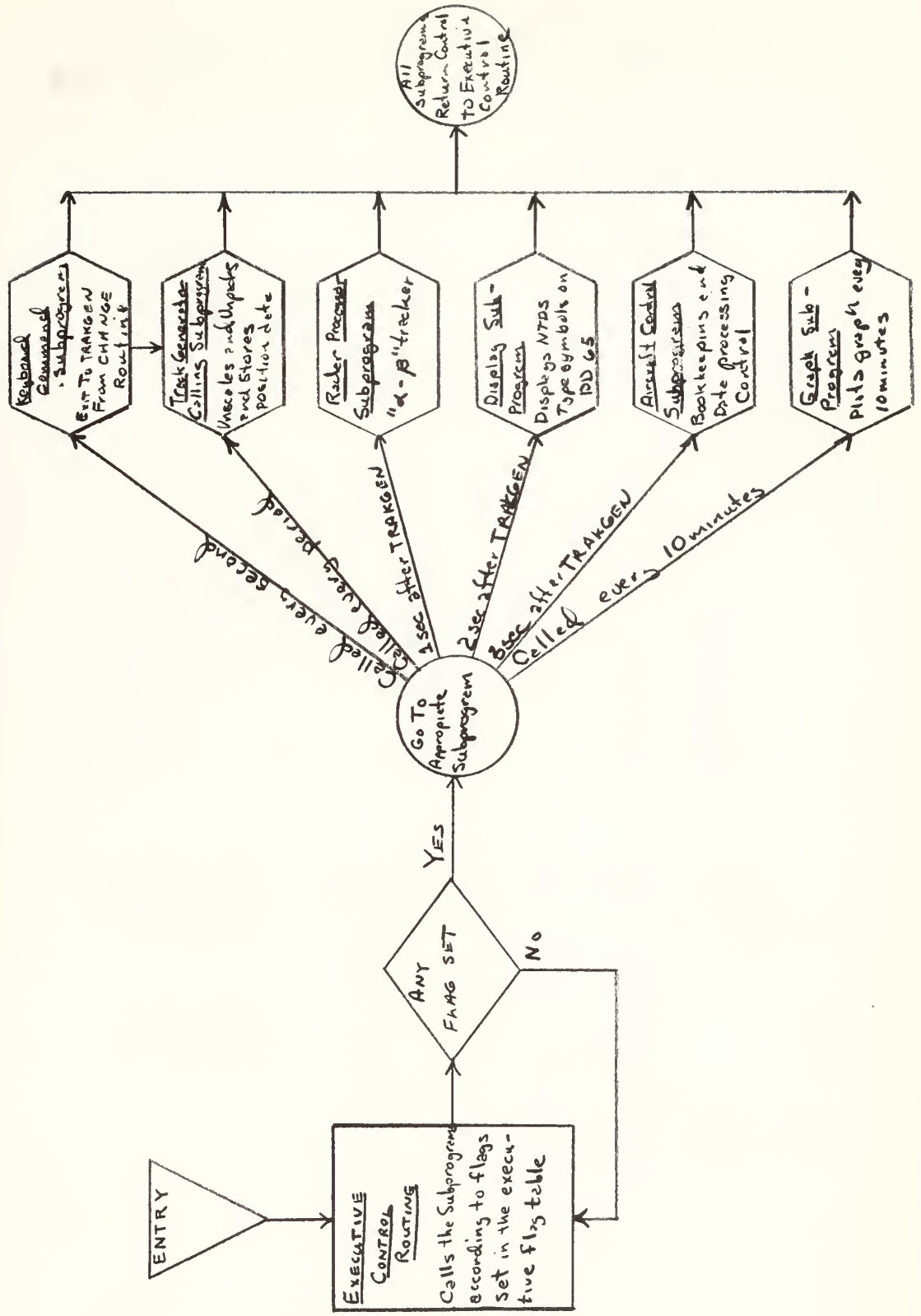

ENTRY
EXECUTIVE CONTROL ROUTINE
Calls the Subprograms according to flags set in the executive flag table
ANY FLAG SET
YES
NO
GO TO Appropriate Subprogram
Called every 4 sec
1 sec after TRAKGEN
2 sec after TRAKGEN
8 sec after TRAKGEN
Called every 10 minutes
Keyboard Command Subprogram
Exit To TRAKGEN From CHANGE Routine
Track Generator Calling Subprogram
Radar Preader Subprogram
"α-β" tracker
Display Sub-Program
Displays NTDS Type symbols on DD 65
Aircraft Control Subprogram
Bookkeeping and Date Processing Control
Graph Sub-Program
Plots graph every 10 minutes
All Subprograms Return Control To Execution Control Routine

Figure 4. Final Block Diagram of SIMONE

BUTTON TABLE	LIGHT TABLE	TRANSFER TABLE	
01	77202	5	P0
02	77204	6	P1
03	77210	6	P2
04	77220	7	P3
05	77240	5	P4
11	77302	4	P5
12	77304	4	P6
↓	↓	↓	
53	77710	5	P27
54	77720	8	P28
55	77740	8	P29

BUTTON TABLE = Code from DD 65 Keyboard 2 switch.

LIGHT TABLE = External Function Code for turning on Computer Controlled light indicator.

TRANSFER TABLE = Number of Characters in the name of the program called and the address of the name. (Used to transfer program name to the buffer.)

Figure 5. Keyboard 2 Control Table

Figure 6. Display Symbols for DD 65

2.2.2 Subroutine TRAKGEN.

2.2.2.1 Early Philosophy. The track generator should be able to generate several tracks, each of which could be maneuvered in three dimensions at the will of the user. It should be able to produce tracks which could simulate aircraft, ships, and submarines. This placed a requirement for a very wide speed range capability on the track generator. The track generator should be capable of being coupled with a track parameter program which would give each track the characteristics of a particular aircraft or vessel.

It was decided to program the track generator as a very fine grain "actual" track generator. This would mean very high resolution capability in three dimensions. The user could then feed this data through a radar simulator program which would deteriorate the data to simulate a specific radar system in a particular environment.

The subroutine should be able to accept preprogrammed track commands and on-line commands from the user. It should then be expanded to allow track control from the tactical data system in the calling program.

2.2.2.2 Initial Programming. The first decision faced in programming the track generator was to determine the number of tracks to be generated. This number would be dependent on user need, available memory space, and program running time. It was felt that there should be a minimum of ten tracks available in order to provide reasonable flexibility. The number 15 was finally chosen mainly because it was convertible to a convenient power of two in binary form.

The first block diagram for TRAKGEN is shown in Fig. 7. Since the subroutine would be generating and storing information on several tracks

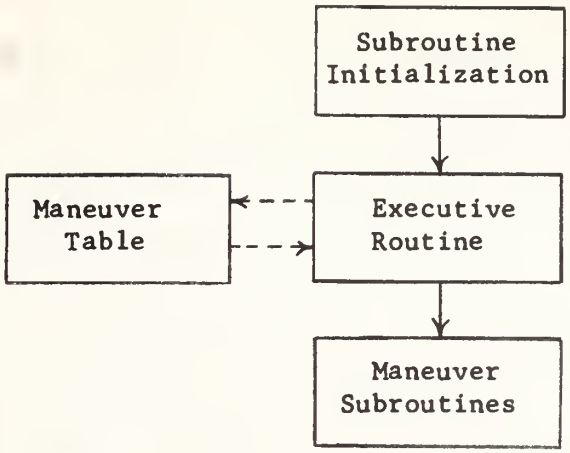


Figure 7. Initial Block Diagram for TRAKGEN

according to a maneuver (command) table, some initialization of matricies and flags would be necessary. It was decided to store the initial position, course, and speed for each track during this phase of the subroutine. Some signal was necessary from the calling program to allow initialization at the proper time. The real-time for the problem would have to be transferred with each call anyway, so a search was made for a way to utilize this as a flag. If the subroutine could be called initially with the real-time equal to zero, the initialization could be accomplished without fear of the flag reappearing later in the program and without the need for a separate flag word.

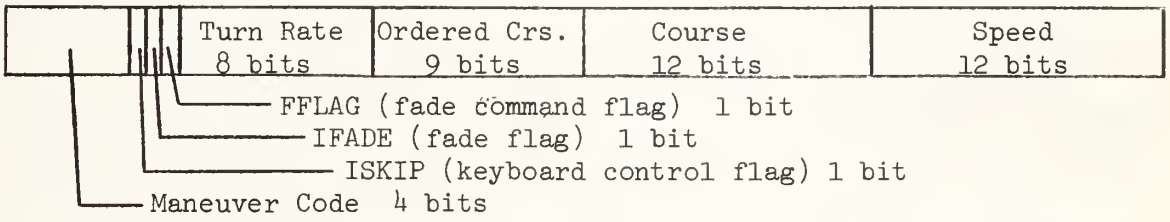
All track information is stored in a 15 x 6 matrix composed of 48 bit computer words. The track number corresponds to the row number in the matrix. The columns are arranged as shown in Fig. 8. Since the memory requirements for the program were unknown, it was felt necessary that track information be packed into the matrix words rather than stored in individual words. The number of bits assigned to each variable was arrived at by trial and error once the maneuver routines were programmed. The final size was determined by a requirement for slow speed tracking at an angle close to the cardinal compass points. Since the computation is done in part in fixed point arithmetic, a slow track would have to move far enough to change by one bit in order to maintain proper course. This was accomplished by balancing the overall range, the minimum track speed, and the calling period and arriving at the necessary bit resolution. The tracking criterion was that a one or two knot track should be able to track at an angle of five degrees off of a cardinal compass heading with a calling period of one second. At the same time, an overall range capability of $\pm$ 250 miles was desired. With the number of bits allotted, a two knot track can meet the five degree requirement with a one second calling period. A calling period of greater than one second allows a one knot track to meet the requirement. Similar reasoning was used to arrive at the altitude packing. The same number of bits were allotted to altitude as to X and Y position for the sake of symmetry. The track course was stored in tenths of degrees to allow turning rates of less than one degree per second with fixed point computation. Since a floating point capability was available in the computer, all quantities were stored in their original units; i.e., course is stored in tenths of

IPOSIT, IPOSIT1 Arrays:

IPOSIT contains the X and Y position information for active tracks.

IPOSIT1 initially contains the initial X and Y position for preprogrammed tracks. After the track is started, IPOSIT1 is used to store position information for faded tracks.

IHEAD Array:

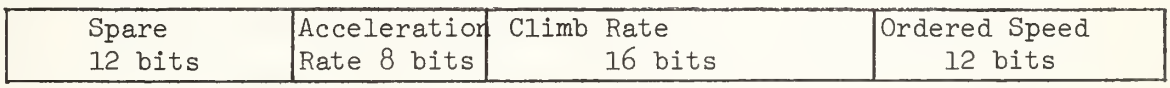

Turn Rate 8 bits
Ordered Crs. 9 bits
Course 12 bits
Speed 12 bits
FFLAG (fade command flag) 1 bit
IFADE (fade flag) 1 bit
ISKIP (keyboard control flag) 1 bit
Maneuver Code 4 bits

JHEAD, JHEAD1 Arrays:

JHEAD contains altitude information for active tracks.

JHEAD1 initially contains the initial altitude for preprogrammed tracks. After the track is started, JHEAD1 is used to store altitude information for faded tracks.

KHEAD Array:



LHEAD Array:

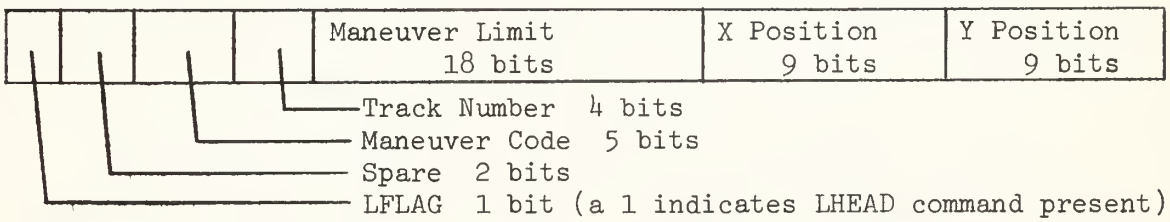

Maneuver Limit 18 bits
X Position 9 bits
Y Position 9 bits
Track Number 4 bits
Maneuver Code 5 bits
Spare 2 bits
LFLAG 1 bit (a 1 indicates LHEAD command present)

Figure 8. Subroutine TRAKGEN Array Formats

degrees rather than an artificial unit such as BAMS (Binary Angular Measure).

The executive routine divides non-initial calls of the subroutine into two parts:

(1) Update maneuver codes.

(2) Update positions.

The first section checks the maneuver table to see if any tracks are due to be maneuvered at this time. If there are maneuver commands, the proper changes are made in the maneuver code stored in the track matrix. Maneuver limits and rates are also stored in proper portions of the matrix.

The second section updates all 15 tracks according to the maneuver code stored in the track matrix. Initially, a print statement would print out what maneuver had been scheduled for each track. After the executive routine was functioning properly, the maneuver routines were inserted in place of the print statements.

The first maneuver routines were:

(1) Constant course routine.

(2) Turn routine.

(3) Climb routine.

(4) Speed routine.

No provision was made to perform more than one maneuver at a time in the initial programming of TRAKGEN.

The constant course routine takes the track speed per second times the calling period in seconds and computes incremental X and Y distances and adds these to the original position of the track.

The climb and speed routines are similar and simply increment altitude or speed linearly for the number of seconds in the calling period.

The turn routine was the last maneuver section programmed and was the most complicated due to the fact that a track can arrive at a given course by turning in either direction. Two methods of generating a curved track were studied. The first was a computation based on turning radius, bank angle, speed, and turn center position. [18]. The second method was a straight line approximation based on speed and turn rate only. After trying both methods, it was decided that the straight line approximation gave satisfactory results with less computation. The turn routine geometry is shown in Fig. 9. In order to insure stability and uniformity regardless of the calling period, the track is incremented in one second segments. Only the positions corresponding to a calling period time are transmitted to the calling program. If a turn will be completed in less than the number of seconds available in the calling period, the track is incremented in one second segments until just short of the ordered course. Then the track is set to the ordered course for the final increment. See Fig. 10.

Tests were run on the turn routine to check the validity of the approximation. A 1000 knot track was programmed to perform repeated 360 degree turns with a calling period of six seconds. A total of eight revolutions was made and a graph output showed that the track accurately retraced its path on each revolution. This indicates that the approximation results in stable arcs and that circles do not degenerate into logarithmic spirals.

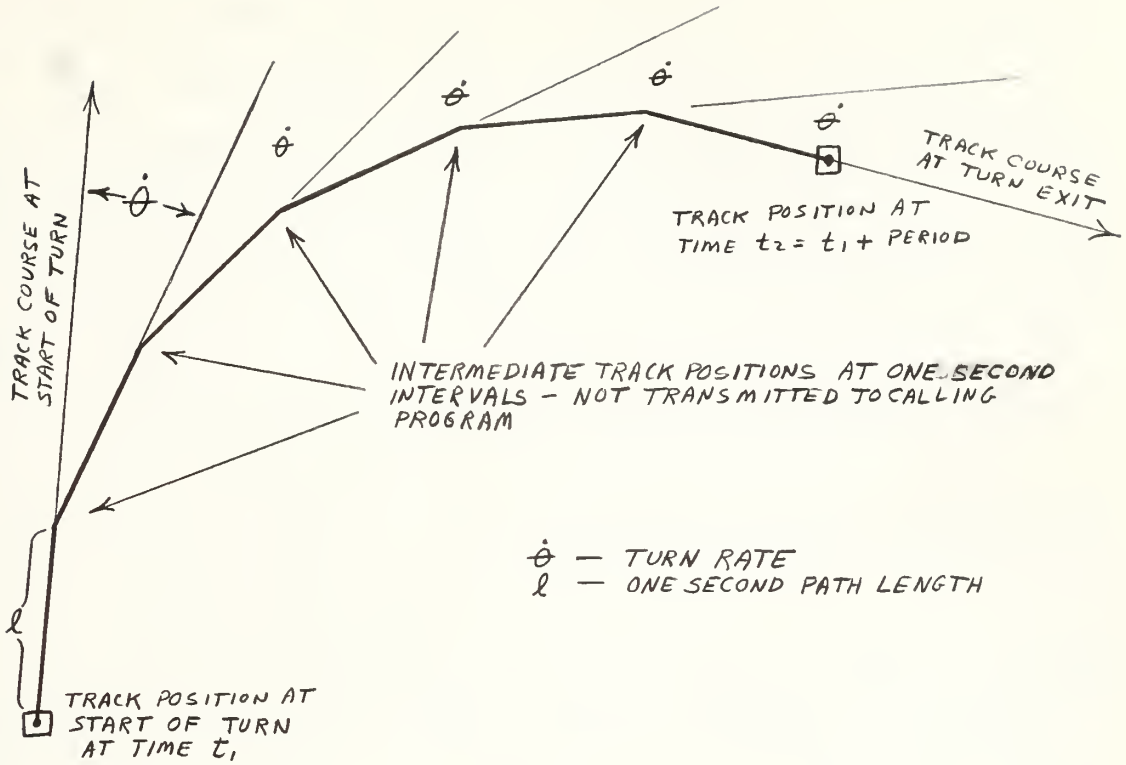

TRACK COURSE AT START OF TURN
TRACK COURSE AT TURN EXIT
TRACK POSITION AT TIME $t_2 = t_1 +$ PERIOD
INTERMEDIATE TRACK POSITIONS AT ONE SECOND INTERVALS - NOT TRANSMITTED TO CALLING PROGRAM
$\dot{\theta}$ — TURN RATE
ℓ — ONE SECOND PATH LENGTH
TRACK POSITION AT START OF TURN AT TIME t_1

Figure 9. Unfinished Turn

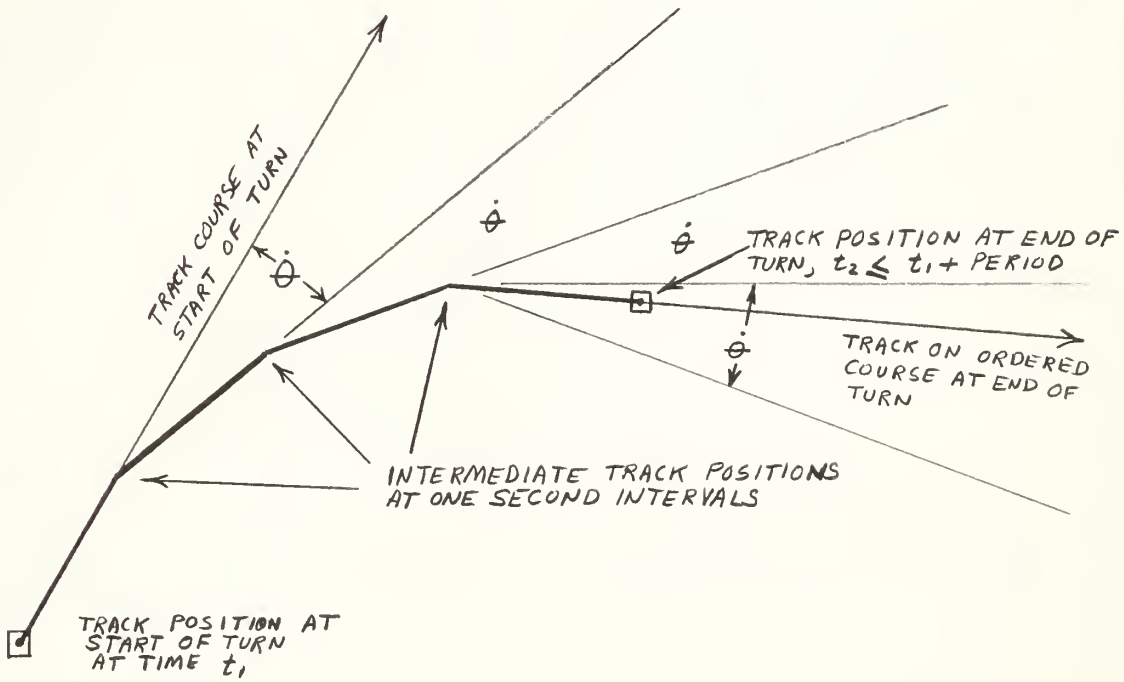

TRACK COURSE AT START OF TURN
TRACK POSITION AT END OF TURN, $t_2 \leq t_1 +$ PERIOD
TRACK ON ORDERED COURSE AT END OF TURN
INTERMEDIATE TRACK POSITIONS AT ONE SECOND INTERVALS
TRACK POSITION AT START OF TURN AT TIME t_1

Figure 10. Completed Turn

2.2.2.3 Expanding the Program. At this point, the track generator was capable of generating tracks which could perform only one maneuver at a time. Some method had to be devised to allow multiple maneuvers such as a climbing turn. It was felt that a proper choice of maneuver code table and maneuver sequencing could solve this problem.

There are two possible methods of controlling the tracks by maneuver codes.

(1) Insert a code to initiate the maneuver and insert a separate code to stop the maneuver.

(2) Insert a code to initiate the maneuver along with the desired maneuver limit and rate.

The second method was chosen since it reduces the number of maneuver table entries by a factor of two. It also corresponds to the normal method of giving commands to operating units in the fleet. Many forms of maneuver code table were tried and discarded as being too cumbersome. There are three basic maneuvers, turn, climb, and accelerate. If these are equated to maneuver codes of two, three, and four, the simple addition of desired maneuvers will result in a distinct maneuver code for all possible combinations of maneuvers. These are shown below:

2 Turn (basic command).
3 Climb (basic command).
4 Accelerate (basic command).
5 Climbing turn.
6 Accelerate in a turn.
7 Accelerate in a climb.
9 Accelerate in a climbing turn.

To fit in with the addition or subtraction of maneuver codes, the code of zero was assigned to a constant course, speed, and altitude track.

These maneuver codes are internal to the program; the external codes being turn, climb, and accelerate only.

Since the only external codes being used were two, three, and four, this left all other unused numbers available for other functions. The external maneuver code decided upon is:

1 Start track.
2 Turn.
3 Climb/dive.
4 Change speed.
5 Fade.
6 Unfade.
8 Scrub track.

The fade command allows a track to disappear from the position array while still being capable of performing all maneuvers. The unfade command returns the track to the position array for normal display. The maneuver code seven is unused.

In the initial program, the maneuver table was read in during the initial call and stored in memory. This severely limited the size of the maneuver table. For this reason, the maneuver table was changed to a data deck table and only one maneuver entry at a time is stored in memory. Each maneuver table entry contains:

(1) Maneuver execution time.

(2) Track number.

(3) Maneuver code.

(4) Maneuver limit.

(5) Maneuver rate.

Besides being controlled from the programmed maneuver table, it was desired that tracks be able to maneuver according to the dictates of the user or according to the computations in the data process section

of the calling program. In order to avoid redundency, it was decided to convert the necessary commands into the same form as that read from a maneuver table data card and to insert these into the program in place of data card information. From this point on, the information is processed the same as a maneuver table entry.

Two sections in the program were developed to handle the interface between the input command and the main subroutine. The Keyboard Control Section is designed to handle commands from the DD 65 console keyboard. It performs checks on the command information to determine if the track called for is available for control. It also sets a flag in the track matrix to disallow further preprogrammed commands since they will be meaningless once the track has been displaced from its preprogrammed track. The one exception to this is the keyboard fade or unfade commands which do not alter the track path and, hence, do not disallow maneuver table commands. All tracks are available for keyboard control with the exception of preprogrammed tracks which have not yet been started by the maneuver table command.

The Data Process Section can control any number of tracks simultaneously. It processes the information from the tactical data section of the calling program into a form suitable to be fed directly into the Keyboard Command Section. Input command information flow is shown in Fig. 11.

2.2.2.4 Future Expansion. Subroutine TRAKGEN can be expanded in several areas. The input maneuver code could be changed so that input commands are inserted in plain language for convenience. The Hollerith word then would select the internal numerical maneuver code.

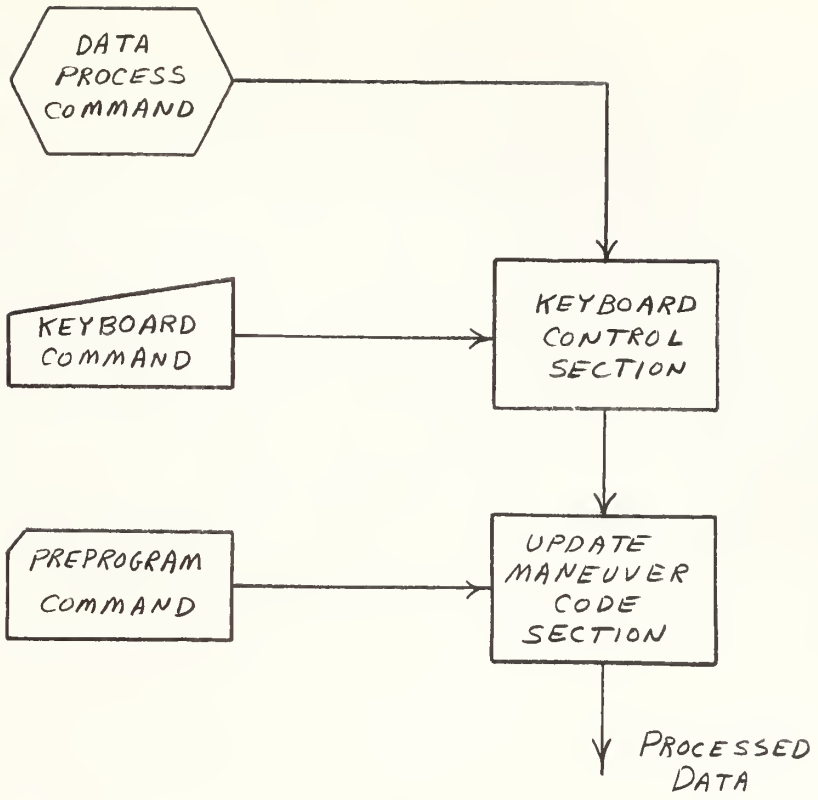


Figure 11. Command Flow Paths

Since the memory capacity of the 1604 has not been fully utilized, it is possible to expand the capability of TRAKGEN to handle more tracks or to have greater range capability. Trakgen requires an additional nine words for each track and the calling program SIMONE requires another 70 cells to allow expanded scratch pad space for each track. The range capability can be expanded by eliminating X, Y, and Z packing and using a complete word for each quantity. This would also allow greater resolution and consequently slower speeds and slower accelerations.

Another expansion of TRAKGEN would be the provision for negative track speeds to allow ships and submarines to back down. This would entail a reworking of the IHEAD array and the pack/unpack sections pertaining to speed and ordered speed.

To keep up with today's high speed aircraft, it would be well if the subroutine could accept maneuver rates in terms of maximum allowable g-forces on the aircraft and pilot. A section could be programmed which would compute these forces as functions of speed and altitude. In this context it would be well to make provision for entering aircraft speeds in mach number as well as well as knots. The g-force section would also prevent aircraft from performing maneuvers which in real life would be physically impossible. It is advisable when doing this to avoid including any classified aircraft parameters to avoid the necessity of classifying the program.

3. EQUIPMENT.

3.1 CDC 1604. The CDC 1604 is a stored-program, general-purpose digital computer, with a storage capacity of 32,768 48 bit words, designed to solve large scale scientific problems and to handle large volume data processing.

The input-output section of the computer handles the flow of information to and from the computer. The computer communicates with external equipment on one of seven channels. Six of these channels are independent buffer channels which provide for the normal input-output exchange of data. The input-output channels are paired, channels 1 and 2, channels 3 and 4, and channels 5 and 6. Channel 7 is a high-speed (4.8 usec per word) transfer channel on which up to eight different equipments may be connected. All communications between the CDC 1604 and the DD 65 were on this channel. By use of the CDC 160 computer as a buffer, communications can be established with the DD 65 using channels 5 and 6. This latter method is similar to that used in the Satellite System. 12 .

3.2 DD 65. The DD 65 consists to two units, the display console and the logic unit. The display console consists of two 12-inch electrostatically deflected tubes. Each tube has a usable display area of 8.5 x 8.5 inches. The left hand tube is normally used to display raw video from one of several radar inputs. The right hand tube is a non-radar tube used to display messages, symbols, etc.

There are several methods of inputting operator commands into the computer. They are by use of an alphanumeric keyboard, a general purpose keyboard, a track-ball controller, and a range switch.

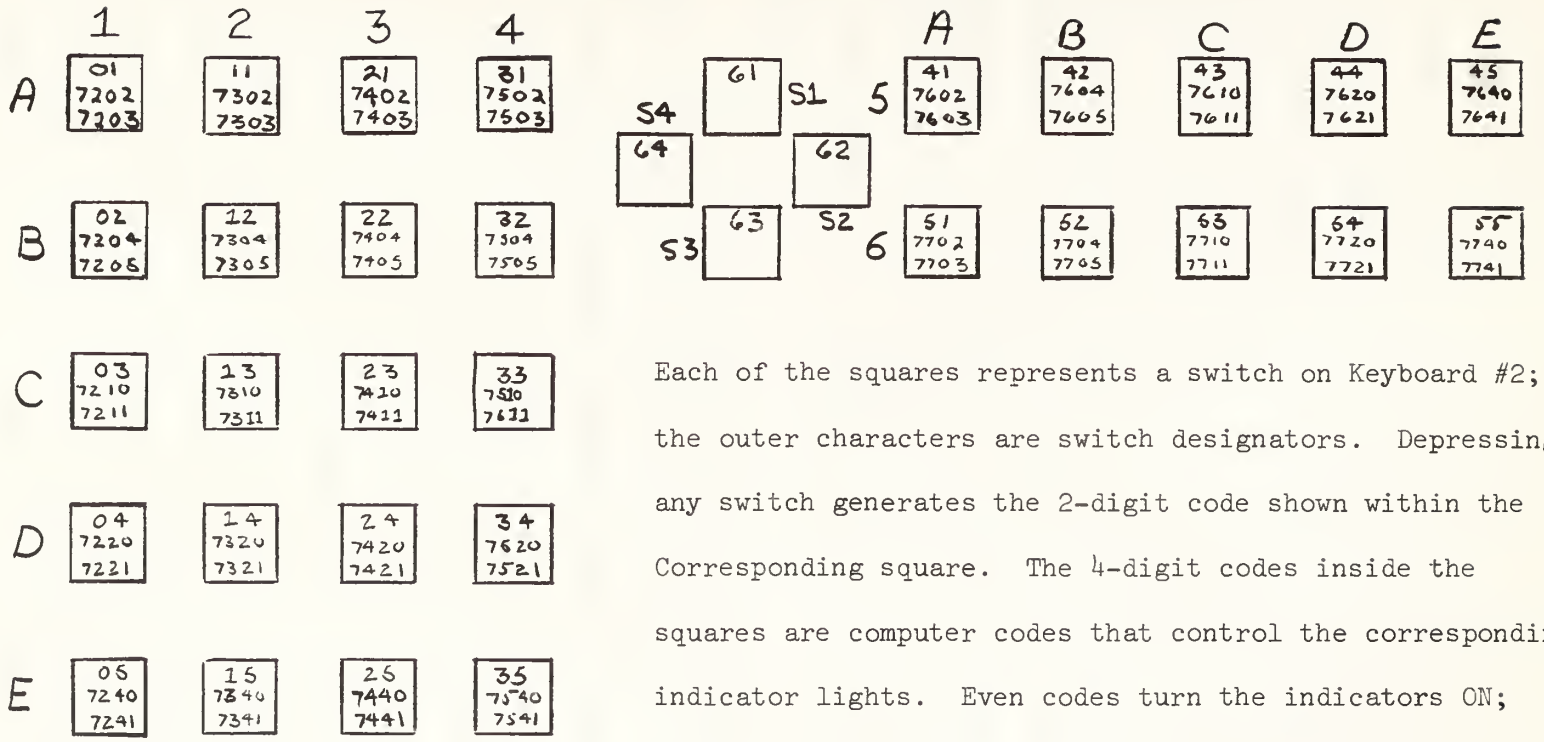


Figure 12. Switch Designations and Input/Output Codes for Keyboard 2

Each of the squares represents a switch on Keyboard #2; the outer characters are switch designators. Depressing any switch generates the 2-digit code shown within the Corresponding square. The 4-digit codes inside the squares are computer codes that control the corresponding indicator lights. Even codes turn the indicators ON; the odd codes turn them OFF.

The logic unit consists of a 1024 24 bit word core memory. Each word is paired to give an effective 512 48 bit word memory. This memory can display data at very high refresh rates. There is a switch inside the logic cabinet that enables one to use only the lower half of memory, thus giving less flicker on the tubes. However, it was found that the flicker was not bad and the advantage of extra memory far out weighed the slight discomfort of the flicker.

3.2.1 Command Inputting Devices. The command inputting devices are designated as Keyboard 1, Keyboard 2, Track Ball, and Range Switch. Keyboard 1 is an alphanumeric typewriter keyboard. There are 64 keys keys on Keyboard 1 of which 60 represent different symbols and three editing keys, i.e., carriage return, space, and tab, and one unassigned key, (code 00).

Keyboard 2 is divided into three functional sections. See Fig. 12. The first section consists of 20 switch units arranged in a 4 x 5 matrix. This group has computer selected light indicators and provisions for insertion of separately coded switch matrix overlays. By use of these overlays, many different functions may be programmed. The second consists of 4 special switch units. These units are grounded to the 60 cps power supply. This enables the switch code to be sent to the computer 60 times a second without having to hit the key but one time. This enables this group of keys to move an editing symbol over the display surface. The third section is a group of 10 switches located over the alphanumeric keyboard. These have associated computer controlled light indicators, also. This set of switches is designed to perform functions common to all overlay programs.

The Track Ball is located to the right of the display tubes on the monitor table top. The X and Y coordinate information is available at all times to the computer and need only be selected.

The last command inputting device is not really a command inputting device, however, it was used for this purpose. This is the Radar Range Switch. This is an 8-position switch which is used to select the range of the display. The 8 positions, ranges and associated codes are shown in Fig. 13.

Switch Position	Code	Switch Position	Code
OFF	0	32	4
4	1	64	5
8	2	128	6
16	3	256	7

Figure 13. Range Switch Coding.

4. Usage.

4.1 General. This routine is intended for use with the normal library currently used by the Computer Facility. Complete compatibility has been maintained.

4.2 Program Format. This routine will normally be called from a reserve library tape. However, if the user wants to modify the program in order to use his own subroutines, the program will be operated under card control. In this case, the following is an example of the normal run using the CDC 405 card reader:

```
SET,5000,66.                        (Memory scratch pad)
CALL,1,FORTBIN.                     (Compiler)
FORTBIN,C,1.                        (Compiler program)
      PROGRAM SIMONE                (Program)
                -
                -
                -
                -
      END
      END
(Blank card)
(Blank card needed for card reader)
SIMONE.
* Data
   -
   -
   -
   -
..
CONTROL,0.
```

To execute this program, load the card reader with the above cards and then type on the typewriter, "control,c,p.". This will start the card reader and all control statements will be printed on the CDC 1612 printer.

After the user has checked out his program, the following methods are suggested:

```
CALL,1,FORTBIN.
FORTBIN,C,1,4.
       PROGRAM SIMONE
                -
                -
                -
                -
       END
       END
(Blank card)
CONTROL,0.
```

This will cause SIMONE to be compiled and placed in library format on tape 4. A pre-compiled program is ready to run. Due to the fact that cells 5000_8 to 20300_8 are used as a scratch pad, SIMONE cannot be called and run. The following program will allow for the proper space being left for the scratch pad:

```
SET,5000,66.
CALL,1,FORTBIN.
FORTBIN,C,4.
       PROGRAM SIMTWO
       CALL SIMONE
       END
       END
(Blank card)
(Blank card)
SIMTWO.
*Data
    -
    -
    -
..
CONTROL,0.
```

This program reduces the recompile time from about eight minutes to approximately 18 seconds.

4.3 The Data Cards.

4.3.1 The first data card contains job identification. It will be reproduced on the graph output. Use columns 1 through 8. This identification could be in the form of a date, run number, etc.

4.3.2 The second and third data cards contain the necessary arguments for the graph outputs:

(1) XSCALE: Columns 6 through 11. X-scale in units per inch. The units are miles for the second data card and minutes for the third data card. The format is E6.0.

(2) YSCALE: Columns 13 through 18. Y-scale in units per inch. The units are miles for the second data card and feet for the third data card. The format is E6.0.

(3) IXUP: Columns 20 and 21. Distance in inches, of the X-axis from the bottom of the graph. Format I2.

(4) IYRIGHT: Column 23. Distance in inches, of the Y-axis from the left of the graph. Format I1.

(5) MODEXAX: Column 25. Determine the mode of the X-axis location 20 . Format I1.

(6) MODEYAX: Column 27. Determines the mode of the Y-axis location 20 . Format I1.

(7) IWIDE: Column 29. Width of graph in inches. Format I1.

(8) IHIGH: Columns 31 and 32. Height of graph in inches. Format I2.

(9) IGRID: Column 34. If IGRID = 1, a 1" x 1" will be superimposed on the graph. Format I1.

The second card furnishes the information for the X - Y position graph and the third card the information for the altitude vs. time graph.

4.3.3 The fourth data card contains SCALE. Use columns 1 through 10. Format F10.0. Due to the variation in altitude capabilities, provision has been made to scale the depth information. Any negative

altitude will be multiplied by SCALE. This will allow for easier interpretation of negative altitudes.

4.3.4 The fifth data card contains IP and IPP. Use columns 1 and 2 for IP and columns 5 through 10 for IPP. Format I2 and I6. IP is the period in seconds for calling TRAKGEN. All other executive routines are called at times based on this period. IPP is the number of seconds between points on the point plot. If IPP is zero, the point plot will not be plotted.

4.3.5 The sixth data card contains the number of preprogrammed tracks, NTRACKS. $0 \leq$ NTRACKS ≤ 15. Right justify in columns 1 and 2.

4.3.6 The seventh data card starts the initial position data. There must be one initial position data card for each preprogrammed track. The position data cards correspond to tracks numbered in consecutive increasing number with the last position being for track number 15. e.g., if three tracks are preprogrammed, the initial position cards are for tracks 13, 14, and 15 in that order.

(1) X-position in miles in columns 1 through 10. X-position may have up to four decimal places. Maximum X is $\pm$ 279 miles.

(2) Y-position in miles in columns 11 through 20. The same comments apply as for X-position.

(3) Altitude in integer feet right justified in columns 25 through 30. Maximum altitude is $\pm$ 98689 feet.

(4) Course in integer degrees right justified in columns 38 through 40.

(5) Speed in integer knots right justified in columns 47 through 50. Maximum speed is 4095 knots. If a zero speed is assigned, a non-zero course must be given or the track will fail to start when ordered.

4.3.7 This data card begins the maneuver table. There must be one data card for each maneuver. The last card in the table must be a non-executable card with a zero in column ten. There is no limit to the length of the maneuver table data deck. Entries are:

(1) Maneuver execution time in seconds right justified in columns 1 through 10. This time need not agree with a calling time since the maneuver will be executed as soon as real-time is equal to or greater than execution time.

(2) Track number right justified in columns 19 and 20.

(3) Maneuver code in column 30:

1 Start track.

2 Turn.

3 Climb/dive.

4 Change speed.

5 Fade.

6 Unfade.

8 Scrub track.

The first code for any track must be a start track command.

(4) Ordered course in integer degrees, ordered speed in integer knots, or ordered altitude in integer feet as appropriate. Right justify in columns 35 through 40.

(5) Maneuver rate right justified in columns 43 through 50.

Insert turn rate in degrees per second with up to one decimal place. $0.1 \leq$ turn rate ≤ 25.5.

Insert climb/dive rate in integer feet per minute. $43 \leq$ climb rate ≤ 65535. Insert acceleration rate in integer knots per second, maximum 255.

Any number of maneuvers can be scheduled for the same execution time. A track can be ordered to perform more than one maneuver at the same time by inserting each maneuver on succeeding cards, e.g.:

265	12	2	180	1.5
265	12	3	5000	1000

This orders track number 12 to start a climbing turn to 180 degrees at a 1.5 degree per second turn rate and to an altitude of 5000 feet at a climb rate of 1000 feet per minute starting at a time of 265 seconds.

4.4 DD 65 Operations.

4.4.1 Hardware. Before starting operations on the CDC 1604, the DD 65 must be ready in all respects to accept information from the CDC 1604. The following check off list is provided to aid in setting up the DD 65.

1. Check for interrupt/sense relay in place.
2. Check for cables in place.
3. Check for memory switch in WHOLE position.
4. Check for mode switch in 1604 only position.
5. Check for Power ON.
6. If the CDC 160 output/input cables are connected, insure that the CDC 160 is on. If the CDC 160 is not on or is inoperative, disconnect cables.

4.4.1.1 Interrupt/sense Relay. Several years ago, because of some logic problems, a modification to the logic cabinet was undertaken. This modification consisted of putting in series with the interrupt lines a relay, that was actuated by the power supply. It was customarily removed when not needed. This year the sense lines were also run through this relay. With the advent of the routine of the sense lines through this relay, it is possible to leave the switch in the OFF position without loading down the sense lines of the 1604. For this reason, the relay may now be left in permanently. However, before running for the first time it will be wise to check this relay. It is located on the inside bottom of logic chassis 2.

4.4.1.2 Cable Connections. Fig. 15 shows the proper connections for the cables. These cables are located at the base of the logic cabinet just below logic chassis 2.

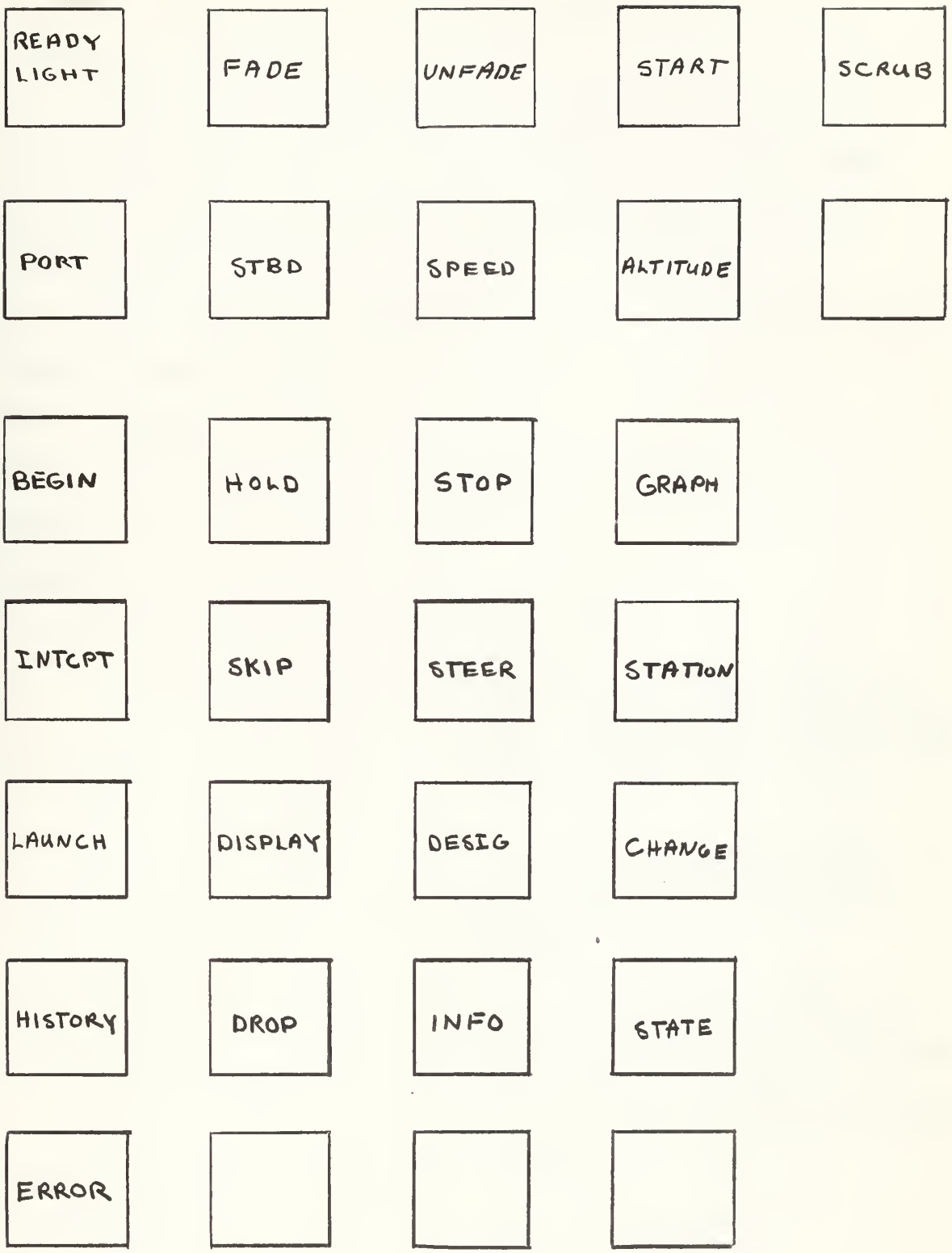


Figure 14. Keyboard 2 Functions

4.4.1.3 Memory Switch. A miniature toggle switch located on the inside edge of logic chassis 1 enables/disables the upper half of memory. Under normal use this switch is in the WHOLE or "down" position, to make maximum use of the memory.

4.4.1.4 Mode Switch. The Mode Switch is located on the front panel of the logic cabinet. This switch has three positions, "160", "Both", and "1604". The normal position for operation of SIMONE is in the "1604" position.

4.4.2 Console Operations. The following Sections deal with the callable routines available to the user.

4.4.2.1 CHANGE.

TASK	To maneuver one of the tracks,
EXAMPLE	CHANGE, N, M, L, R, X, Y, Z. $
ARGUMENTS	7
	N = Track number
	M = Maneuver called--START, SCRUB, PORT, STBD, SPEED, ALTITUDE, FADE, OR UNFADE. If the Maneuver called is SCRUB, FADE, or UNFADE, then a period and $ follow M.
	L = Limit--initial course for START and desired course for PORT or STBD. This argument is desired speed for SPEED and desired altitude for ALTITUDE.
	R = Rate--initial speed for START, ten times the rate of turn for PORT or STBD, rate of climb/dive for ALTITUDE, and acceleration/deceleration for SPEED. If omitted when interpretated as a rate, then standard rates will be assumed.

X = Initial X position for START only.

Y = Initial Y position for START only.

Z = Initial Z position for START only.

4.4.2.2 DESIG.

TASK — To designate a track.

EXAMPLE — DESIG,TYPE.$

ARGUMENTS — 2

TYPE = Type of target-- F will assign friendly symbol, H will assign hostile symbol, and if omitted, ownship symbol will be assigned.

HOOK = Target under hook will be assigned symbol designated by TYPE.

4.4.2.3 DISPLAY.

TASK — To change the tube on which raw radar data displayed.

EXAMPLE — DISPLAY.$

ARGUMENTS — 0
This routine will cause the raw data to be displayed on the opposite tube from which it is now displayed.

4.4.2.4 DROP.

TASK — To cause a history track to be erased.

EXAMPLE — DROP.$

ARGUMENTS — 1

HOOK = Target under hook will have its history track erased.

4.4.2.5 GRAPH.

TASK — To cause a graph to be plotted.

EXAMPLE — GRAPH.$

ARGUMENTS

0
This routine will cause a graph to be plotted that will cover the period from the last regular plot to the present time. The next regular plot will cover the time from now till then.

4.4.2.6 HISTORY.

TASK

To cause history points to be displayed.

EXAMPLE

HISTORY,A,M.$

ARGUMENTS

3

A = Number of points desired. This must be between 0 and 24. A number over 24 will be reduced to 24. If omitted, 12 points will be plotted.

M = Point mode indicator. If omitted, points will be plotted every period. M will cause points to be plotted every minute.

HOOK = Target under hook will have its history plotted.

4.4.2.7 HOLD.

TASK

To cause the problem to pause.

EXAMPLE

HOLD.$

ARGUMENTS

0
This routine puts the program into a wait loop. This wait loop is terminated upon the second striking of the HOLD switch.

4.4.2.8 INFO.

TASK

To provide information on targets.

EXAMPLE

INFO.$

ARGUMENTS

1

HOOK = Information about target under hook will be displayed. See Appendix I for format.

4.4.2.9 INTCPT.

TASK — To initiate an intercept.

EXAMPLE — INTCPT,C.$

ARGUMENTS — 2

C = CAP number of interceptor

HOOK = Target under hook will be intercepted by CAP

4.4.2.10 LAUNCH.

TASK — To launch a CAP.

EXAMPLE — LAUNCH,C,R,B,T.$

ARGUMENTS — 4

C = CAP number of CAP to be launched

R = Range from the TASK FORCE center of CAP station

B = Bearing from the TASK FORCE center of CAP station

T = Type of CAP (2 through 7)

If arguments R and B are omitted, Station will be assumed to be under hook. If argument T is omitted, type 7 interceptor is assumed. To designate type and use hook for station, zeros must be placed in R and B.

4.4.2.11 SKIP.

TASK — To cause an intercept to be skipped.

EXAMPLE — SKIP,C.$

ARGUMENTS — 1

C = CAP number of intercepting CAP

4.4.2.12 STATE.

TASK	To display the State of the CAP.
EXAMPLE	STATE,C.$
ARGUMENTS	1
	C = Cap number. State format in Appendix I.

4.4.2.13 STATION.

TASK	To Station a CAP.
EXAMPLE	STATION, C,R,B.$
ARGUMENTS	3
	C = CAP number
	R = Range from TASK FORCE center of CAP station
	B = Bearing from TASK FORCE center of CAP station
	If R = 0, then station will be assumed to be under the hook.

4.4.2.14 STEER.

TASK	To cause a CAP to be sent to TASK FORCE center.
EXAMPLE	STEER,C.$
ARGUMENTS	1
	C = CAP number

4.4.2.15 STOP.

TASK	To terminate the problem.
EXAMPLE	STOP.$
ARGUMENTS	0

4.4.2.16 BEGIN.

TASK	To start the problem.
EXAMPLE	BEGIN.$
ARGUMENTS	0
	This routine starts the problem and the number of tracks under user control is displayed on the DD 65.

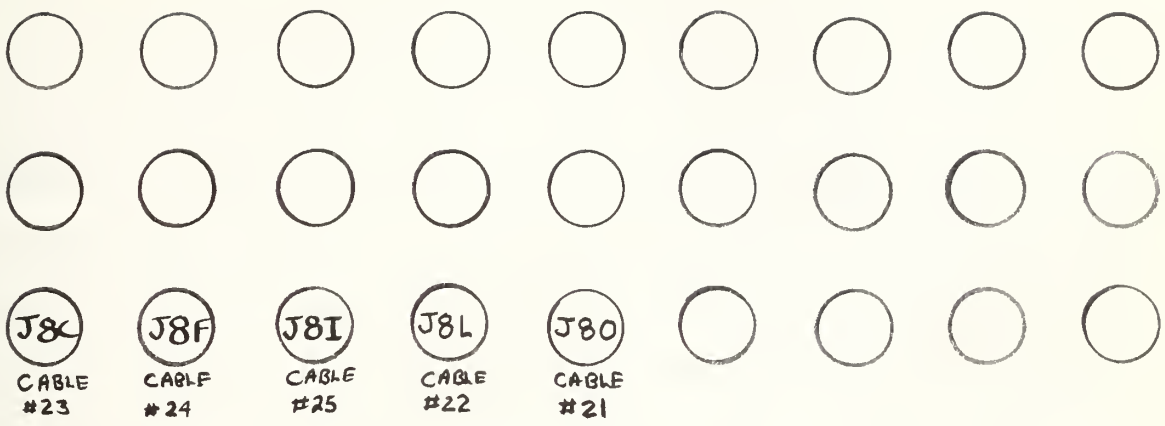


Figure 15. Cable Connections

5. Equipment and Logical Difficulties.

Some difficulties were encountered which were the result of both equipment logical short comings and equipment interaction.

5.1 DD 65 Display Console. Keyboard 1, the alphanumeric keyboard, when selected for input remains selected even after the input has been completed. If the keyboard were again selected for input, the processor is indefinitely delayed when the input is attempted. This limitation is the result of the cumbersome electromechanical keying system used, and has been previously avoided by selecting another display unit external function code. The deselect code previously used was SELECT RADAR TARGET DATA TO AUXILIARY EQUIPMENT. This code seemed to work well and was used to positively deselect both Keyboards 1 and 2.

It was also found that when one used the code SELECT RADAR RANGE SWITCH followed by SELECT TRACK BALL "X" that on some occasions the computer would be delayed indefinitely trying to input the X-cordinate. On the time the 1604 was not delayed, the next time an input from Keyboard 1 was attempted the code 760 was transferred to the computer. To correct for this the code for SELECT RADAR TARGET DATA TO AUXILIARY EQUIPMENT was used to deselect again. It appears that whenever an input code is selected it takes an output code to deselect the input code and vice versa. This points out the fact that there is no single code that deselects previously set selects.

5.2 CDC 1604. At this time there still remains an interaction between the 1604 and the DD 65 that has not been explained. Occasionally, during an update of the DD 65's memory or during an erasing of the DD 65's memory, the 1604 ends up with a 00007 in the upper address portion of

cell 00007. Since the upper instruction is an unconditional jump, the computer just sits there looping on the same cell. The logic prints show this to be impossible and the logic cards that actuate the interrupt lockout have been changed to no avail. At this time there is no answer.

6. Conclusions and Acknowledgments.

6.1 Conclusions. A general purpose track generator has been implemented based on the following concepts:

(1) Suitable for on-line simulation as well as system analysis studies.

(2) Applicable to both anti-air and anti-submarine warfare operations.

(3) Provision for operator interaction made available for exercising "console control" in gaming situations.

The tracking package provided is intended to be used as a basic tool in:

(1) Computer simulation analysis of weapons systems performance, e.g., interceptor-missile mission.

(2) Illustration and evaluation of combat direction system functions, e.g., NTDS, ATDS.

(3) Any system studies requiring complex track motion data on multiple targets, e.g., track-while-scan radar system performance.

The following major routines have been fully checked out under operating conditions:

(1) Subroutine TRAKGEN (Track Generator).

(2) Executive Control Routine.

(3) Display Subprogram.

(4) Radar Processor Subprogram.

(5) Keyboard Command Routine (Program Control Routine).

(6) Graph Output Routine.

(7) All keyboard callable routines except the HISTORY Routine.

In addition, an Aircraft Control Subprogram has been incorporated into the program listing. While reasonably close to final form, it has not yet been successfully tested with the system.

In the course of the work several interface problems on the 1604 - DD 65 channel 7 hookup were brought to light and corrected. These problems were:

(1) The DD 65, when turned off, loading the sense lines of the CDC 1604.

(2) The CDC 1604 being unable to input information from the track ball without first positively deselecting any previous input selection made by the CDC 1604.

(3) Incorrect cable listings in [10] for channel 7 hookup.

In addition, the following engineering difficulties have appeared but have not been corrected:

(1) An apparent random failure of the interrupt lockout feature of the CDC 1604 resulting in the computer remaining in a loop executing the instruction "SLJ (7)" while PAR equals 00007.

(2) Apparent incomplete decoding of certain external function codes or "leaking" of other signals into the external function lines of the DD 65 resulting in random selects of the computer controlled light indicators.

(3) Sensitivity of data transfer to timing adjustments in the CDC 1607 tape units resulting in parity errors if they are out of tolerance (Not corrected, but bypassed by use of memory as a scratch pad).

Upon analysis of the data obtained over the past five months, the duty cycle has been calculated to range from 0.18 to 0.26. The smaller duty cycle occurred during a 15 track problem. These figures were a result of the duty cycle routine embedded in the program. They closely correlate with theoretical data. The duty cycle indicates that the only constraint on expanding the program is that of computer memory size.

6.2 Acknowledgments. The authors wish to express their appreciation to Professor Mitchell L. Cotton for his aid and encouragement in the preparation of this thesis. In addition, the authors would like to thank Major Thomas Kauffman, USMC for his liason with Litton Systems, Inc., Data Systems Division who provided us with much information concerning simulation and smoothing systems; Lieutenant Commander J. V. Reynolds, USN, Fleet Computer Programming Center Pacific, who provided us with data concerning the Naval Tactical Data System and their approach to the simulation problem; Mr. Leon Spors and Mr. John Plesac of Control Data Corporation for their assistance in studying the interface problem; and Mr. Walter Landaker for his excellent maintenance of the DD 65.

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APPENDIX I - A

1. Identification.

Title: SIMONE

Category: Control Routine

Programmer: E. L. Borden

Organization: U. S. Naval Postgraduate School

Date: April 1965

2. Purpose.

This control routine provides a means to control a simulated tactical data system from the DD 65.

3. Executive Called Subprograms.

3.1 1F-Display Subprogram. This program calls PRINT and causes both raw and smoothed data to be displayed on the DD 65.

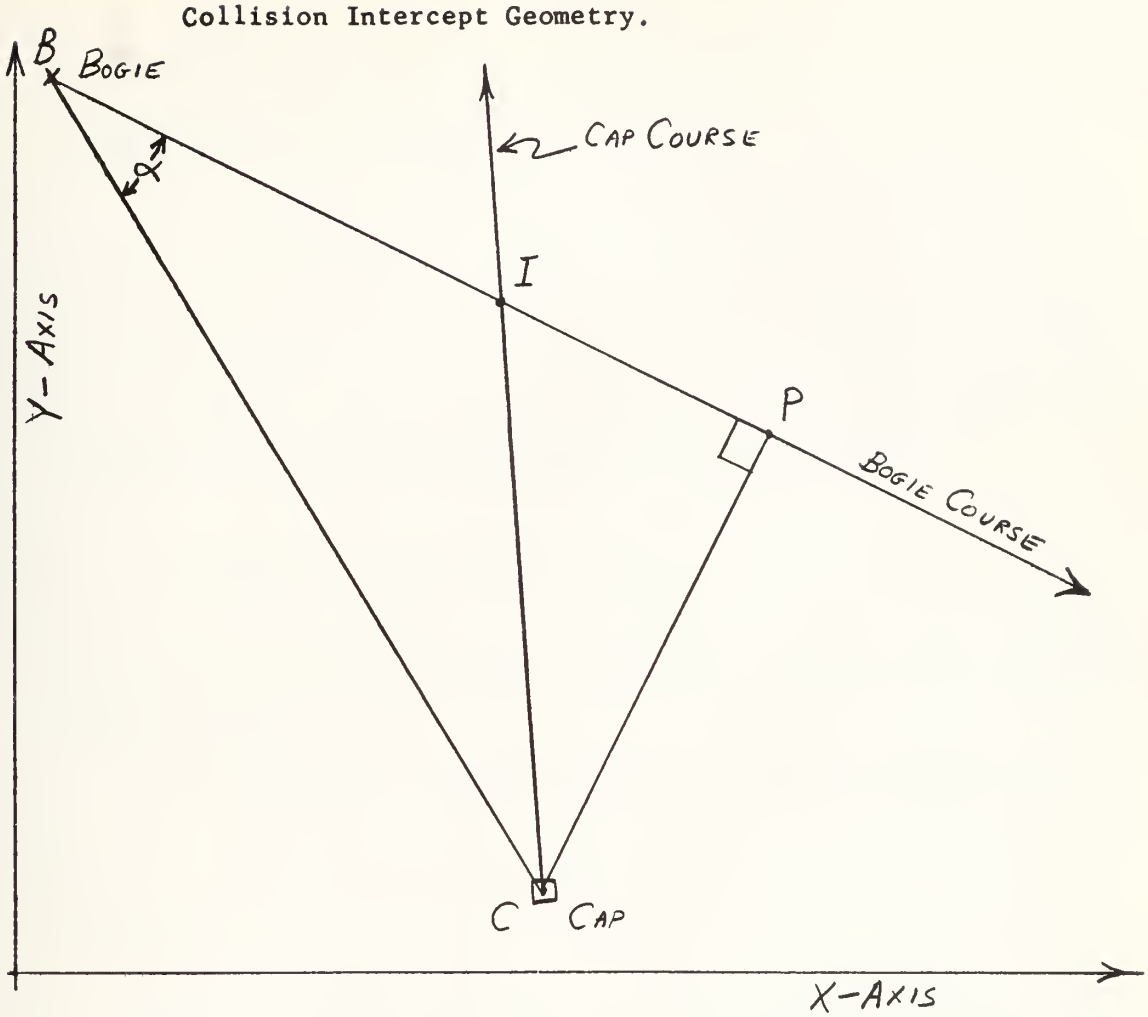
3.2 1G-Radar Processor. This subprogram uses the basic "alpha-beta" smoothing equations to process the radar data. The equations can be found in [1].

3.3 1GR-10 Minute Graph Subprogram. This program reads from the memory scratch pad and processes the data for calling DRAW to output the permanent graph record.

3.4 1INT-Aircraft Control Subprogram. This program performs the bookkeeping on fuel and ammunition loading for friendly aircraft and allows for control of these aircraft by the data process section. See Fig. I-1 for the collision intercept geometry.

APPENDIX I

Collision Intercept Geometry.



Alfa = Absolute value of Bogie Course minus Cap Bearing from bogie.

I = Point of intercept.

CP = N (Perpendicular distance from Cap to Bogie track).

BP = M (Distance from Bogie to point P).

V_b = Velocity of Bogie.

V_c = Velocity of Cap.

Figure I-1

APPENDIX I

In order for the Cap to intercept the Bogie at point I, the following equations must be true:

$$BI = V_b t \qquad \& \qquad CI = V_c t$$

We assume the following equation to be true. If it is not the case, BI will be negative and a collision intercept will be impossible since the intercept will take place somewhere to the right of P.

$$(CI)^2 = (M - BI)^2 + N^2$$

Solving the above equation simultaneously we end up with a quadratic equation in BI.

$$(V_c - V_b)^2 \cdot (BI)^2 + (2MV_b^2) \cdot (BI) - V_b^2 (M^2 + N^2) = 0$$

Solution:

$$(BI)^2 + \frac{2MV_b^2}{(V_c^2 - V_b)^2} \cdot (BI) - \frac{V_b^2}{(V_c^2 - V_b)^2} \cdot (M^2 + N^2) = 0$$

$$BI = \frac{V_b^2 M}{(V_c^2 - V_b^2)} \cdot \left[-1 \pm \sqrt{1 + \left(1 + \left[\frac{N}{M}\right]^2\right)\left(\left[\frac{V_c}{V_b}\right]^2 - 1\right)} \right]$$

This is the basic equation that must be solved in order to determine if an intercept can be made. If two positive values of BI exist, the smaller of the two will be the shortest intercept.

3.5 1K-Keyboard Command Subprogram. This program sets the range scale factor and positions the hook on the right hand tube of the DD 65. This routine also checks to see if there are any commands from the DD 65 to be executed. If there are commands to be executed then control is passed to the 1P-Program Control Routine.

3.6 1TG-Track Generator Calling Subprogram. This program calls TRAKGEN, unscales and unpacks the X, Y, and Z positions and records these values on the memory scratch pad for future graphs.

4. DD 65 Called Routines.

4.1 1C-Change Routine. This is a seven argument routine, which is used to control tracks.

4.1.1 Arguments.

1A	Track Number
2A	Maneuver Called
3A	Variable Argument (Limit)
4A	Variable Argument (Rate)
5A	X Position
6A	Y Position
7A	Z Position

The variable arguments are interpreted according to the maneuver called. The interpretations are:

Maneuver	3A	4A
START	Course Desired	Speed Desired
SCRUB	Ignored	Ignored
PORT	Course Desired	10 x Turn Rate
STBD	Course Desired	10 x Turn Rate
SPEED	Speed Desired	Acceleration
ALTITUDE	Altitude Desired	Dive/Climb Rate
FADE	Ignored	Ignored
UNFADE	Ignored	Ignored

Arguments 5A, 6A, and 7A are used only when the maneuver START is called, at all other times they are ignored.

When the argument is a rate (4A with PORT, STBD, SPEED, and ALTITUDE), omitting the argument will cause standard rates to be entered. These rates are:

PORT	1.5 Degrees per second
STBD	1.5 Degrees per second
SPEED	10 knots per second
ALTITUDE	5000 feet per minute

4.2 1D-Display Routine. This is a zero argument routine that complements the D-Flag. The Display Subprogram uses the D-Flag to determine on which tube the raw data is to be displayed. A negative D-Flag will cause the raw data to be displayed on the right hand tube while a positive D-Flag will display the data on the left hand tube.

4.3 1J-Designate Target Routine. This routine is a two argument routine that calls the 3JO routine to determine the second argument. The target under the hook will be designated according to the following:

Argument	Designation
O(zero)	Own Ship
H	Hostile Track
F	Friendly Track

When a track is designated friendly and it is an aircraft, its interceptor type is determined by the condition of the least significant bit in cell 50 (Job time clock). A 0 assigns a type 7 and a 1 assigns a type 3.

4.4 1L-History Routine. This routine is a three argument routine. The first argument is the number of points desired. This argument may be any number between 1 and 24. Any number greater than 24 will be reduced to 24. If the argument is omitted, then 12 points will be plotted. If the second argument is anything other than zero, then the first argument will be interpreted as the number of minutes of past history with one point for each minute. The third argument, the track number, is filled by the Hook Routine. Up to two tracks may have past history plotted. If a third track is requested, the first track will be dropped.

4.5 1PQ-Hold Routine. This is a zero argument routine that places the program in a wait loop. The second hitting of the hold switch will resume the program.

4.6 1Q-Intercept Command Routine. This is a two argument routine that calls the Hook Routine to fill the second argument, the BOGEY track number. The first argument is the CAP number of the interceptor. This routine sets the necessary flags which signal the Aircraft Control Subprogram to initiate an intercept.

4.7 1R-Drop History Routine. This is a one argument routine that has its argument, the track number, filled by the Hook Routine. The history being displayed on the hooked track will be dropped upon execution of this routine.

4.8 1S-Stop and Critique Routine. This is a zero argument routine that causes the problem to be terminated and the final graph to be plotted.

4.9 1ST-State Routine. This is a one argument routine which causes one of the following messages to be displayed on the DD 65 depending upon the actual state of the interceptor.

```
STATE REPORT ON CAP   xx

      PLUS
AMMO MINUS / OXYGEN PLUS / FUEL xxxx POUNDS / TIME xxxxZ.
      ZERO

TYPE  x
```

4.10 1TT-Information Routine. This is a one argument routine that has its argument filled by the Hook Routine. The following are examples of the types of information messages that appear:

```
      INFORMATION
TRACK  NR  14
BOGEY  E3
COURSE  350, SPEED 450, ALTITUDE 35000.
RANGE:   120 MILES.
BEARING:  80 DEGREES.
FROM TASK FORCE CENTER

      INFORMATION
TRACK  NR  13
SKUNK  D
COURSE  35, SPEED 13.
RANGE: 12000 YARDS.
BEARING  270 DEGREES.
FROM OWN SHIP
```

```
      INFORMATION
TRACK  NR  3
GOBLIN E
COURSE 270, SPEED 4, DEPTH 200.
RANGE:  3000 YARDS.
BEARING:   5 Degrees
FROM OWN SHIP
```

Speeds are in knots and depth is in feet.

4.11 1U-Steer Command Routine. This is a one argument routine which sets the necessary flags which signal the Aircraft Control Subprogram to steer the CAP specified by the argument.

4.12 1V-Station Command Routine. This is a three argument routine. The arguments are:

1A	CAP number
2A	Range of Station from TF Center
3A	Bearing of Station from TF Center

If argument 2A is zero or omitted, then the station will be assumed to be under the hook. This routine sets the necessary flags which signal the Aircraft Control Subprogram to station the CAP.

4.13 1W-Skip Command Routine. This is a one argument routine that sets the necessary flags which signal the Aircraft Control Subprogram to cause the CAP listed in the argument to disengage and return to station.

4.14 1X-Launch CAP Command Routine. This is a four argument routine. The arguments are:

1A	CAP number
2A	Range of Station from TF Center
3A	Bearing of Station from TF Center
4A	Type of interceptor

If argument 2A is zero or omitted, then the hook is assumed to be over the station. This routine sets the necessary flags which signal the Aircraft Control Subprogram to launch a CAP and send him to the designated station.

4.15 1Z-Begin Routine. This is a zero argument routine that starts the program and calls TRAKGEN with time equal to zero. This routine also causes the number of tracks under Keyboard control to be displayed on the DD 65. The format of the message is:

07 TRACKS UNDER YOUR CONTROL.

5. Control Routines.

5.1 1T Executive Control Routine. This routine follows the basic philosophy of the executive control routine described in Section 2.2.1.1 of the main body and in [14] .

5.2 1P-Program Control Routine. This routine functions as the basic operator-computer communications link, decodes control statements, packs arguments for routines; then passes control to the routine designated.

6. Miscellaneous Routines.

6.1 3JO-Hook Routine. This routine is used by many other routines and cannot be called separately. It hooks any track within the range acquisition gate. The range acquisition gate is variable and changes depending upon the range scale setting. The gate sizes are:

Range Scale (miles)	Gate
256	8.0 x 8.0
128	4.0 x 4.0
64	2.0 x 2.0
32	1.0 x 1.0
16	.5 x .5
8	.25 x .25
4	.125 x .125

There is no acquisition gate for altitude. If two or more targets are within the X and Y gates but at different altitudes, the target with the lowest track number will be hooked. If there is no target within the gate, the error message "TRACK NOT HOOKED" will be displayed and control will return to the Executive Control Routine.

6.2 1Y-Find CAP Number Routine. This routine is used in conjunction with any routine that uses CAP number instead of track number as an argument. This routine searches the TRACK array to determine the track number of the CAP. If the result of the search is negative, the message "CAP xx NOT AIRBORNE" is displayed on the DD 65.

6.3 1ZZ-CAP Number and Station Routine. This routine calls the CAP Number Routine to determine track number and then computes the X and Y coordinates of the designated station.

7. Error Stops.

An incorrect number of tracks, i.e. number greater than 15, on the sixth data card will cause the program to execute a selective stop. The following error message will be displayed.

NTRACKS $\geq$16 CHECK DATA DECK AND TRY AGAIN

The program may be started again after correcting the data deck by hitting RUN on the CDC 1604.

8. Error Messages.

Message	Meaning
PROGRAM NOT CALLED	The program called was not listed in the Program Name Table.
TOO MANY ARGUMENTS	Too many arguments were listed for the program called or an unauthorized argument was used (i.e. ⩾, :, ∧, etc.)
2ND ARGUMENT ILLEGAL	An illegal maneuver was called for or the argument for the Desig Routine was not on H, P, or 0 (zero).
TARGET NOT HOOKED	No target was within the range acquisition gate.
NTRACKS ⩾ 16 CHECK DATA DECK AND TRY AGAIN	See 7.

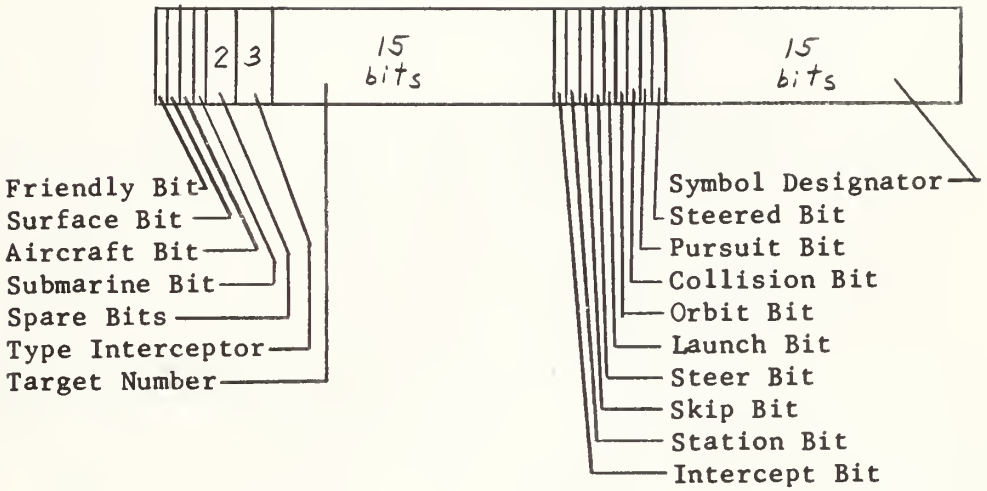
9. Information Messages from Aircraft Control Subprogram.

Message	Meaning
CAP xx UNABLE TO INTERCEPT - FUEL	CAP does not have enough fuel to reach the intercept point
CAP xx UNABLE TO INTERCEPT - AMMO	CAP does not have any ammunition left aboard
CAP xx LOW STATE	CAP has just enough fuel to return to carrier
CAP xx MAYDAY...MAYDAY...	CAP out of fuel, Ditching
CAP xx INTERCEPTING - UNABLE TO RETURN	CAP does not have sufficient fuel to return to the carrier after making an intercept

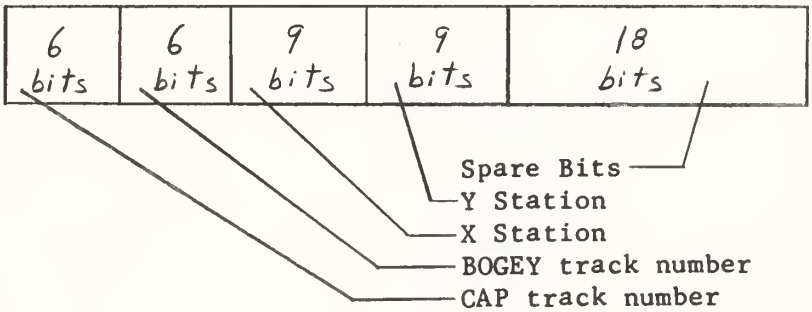
CAP xx FAMISHED	CAP has no station assigned
CAP xx POOR INTERCEPT	CAP unable to make collision intercept and is in a pursuit intercept
SPLASH BOGEY Exx	CAP destroyed BOGEY Exx
HEADS UP BOGEY Exx	CAP unable to destroy BOGEY Exx

10. Array Formats.

10.1 TRACK Array.



10.2 TRACK1 Array.



Interrupt Routine

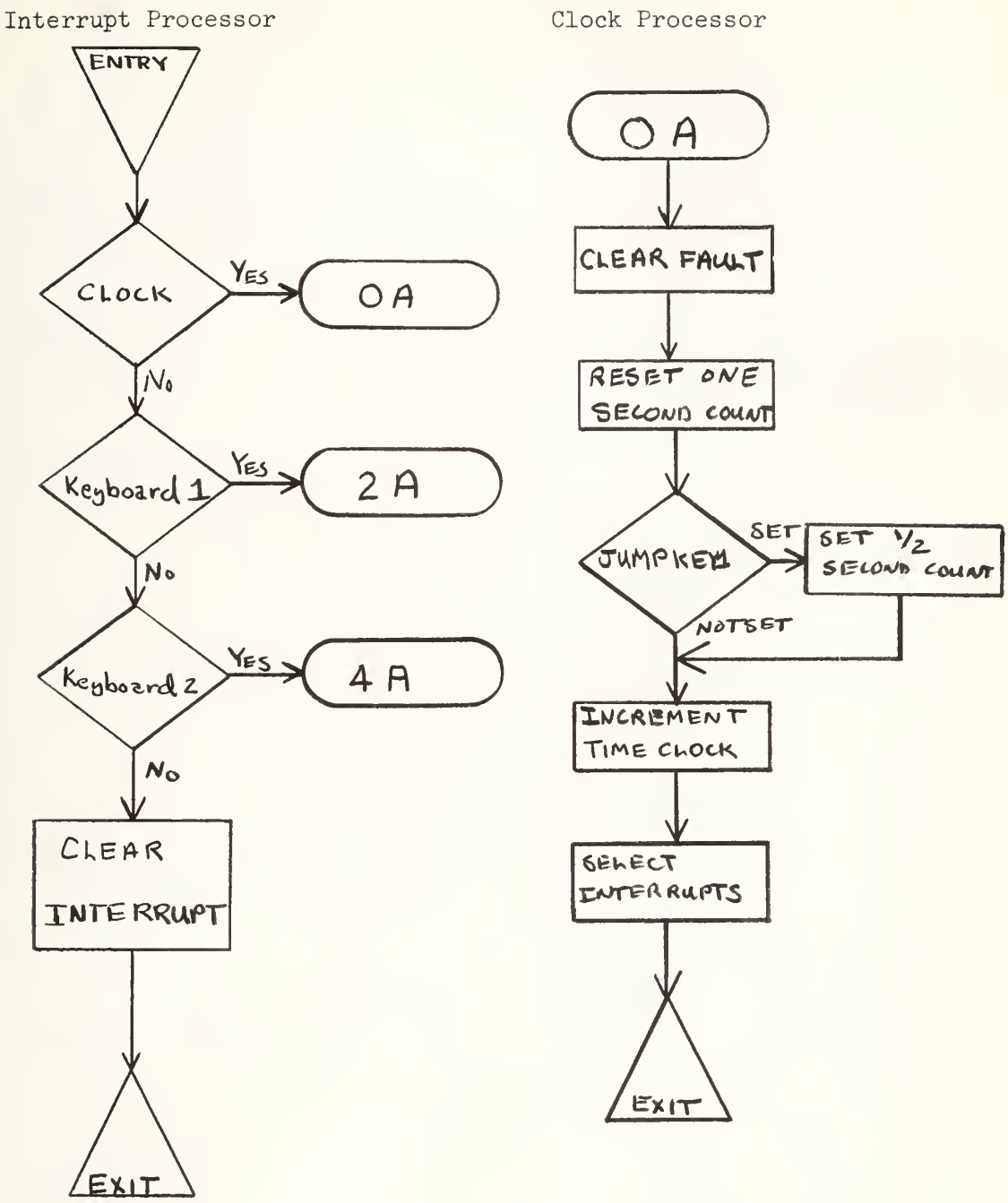


Figure I-2

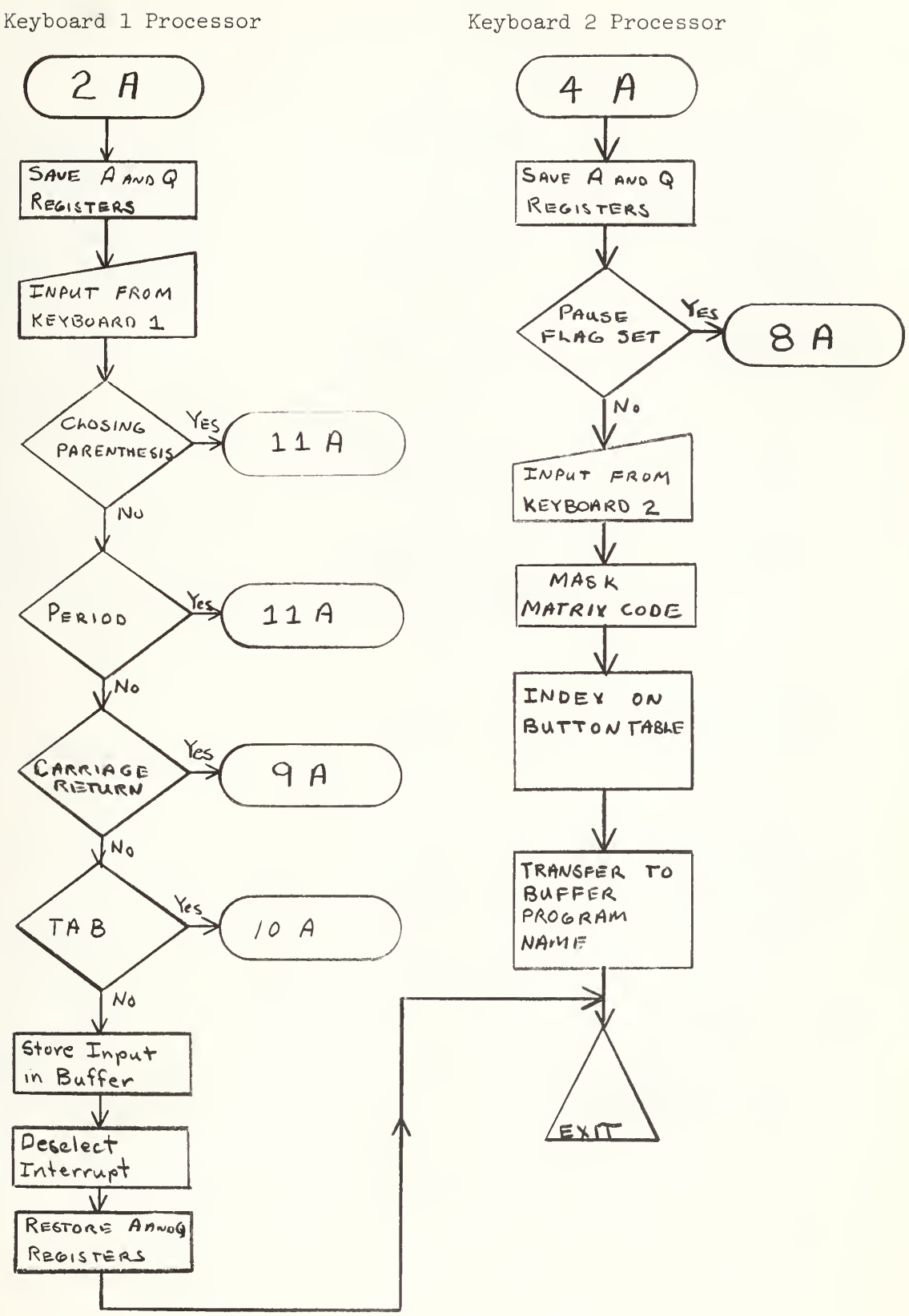

Keyboard 1 Processor
2 A
SAVE A AND Q REGISTERS
INPUT FROM KEYBOARD 1
CHOSING PARENTHESIS
YES
11 A
NO
PERIOD
YES
11 A
NO
CARRIAGE RETURN
YES
9 A
NO
TAB
YES
10 A
NO
Store Input in Buffer
Deselect Interrupt
RESTORE ANNOG REGISTERS
Keyboard 2 Processor
4 A
SAVE A AND Q REGISTERS
PAUSE FLAG SET
YES
8 A
NO
INPUT FROM KEYBOARD 2
MASK MATRIX CODE
INDEX ON BUTTON TABLE
TRANSFER TO BUFFER PROGRAM NAME
EXIT

Figure I-3

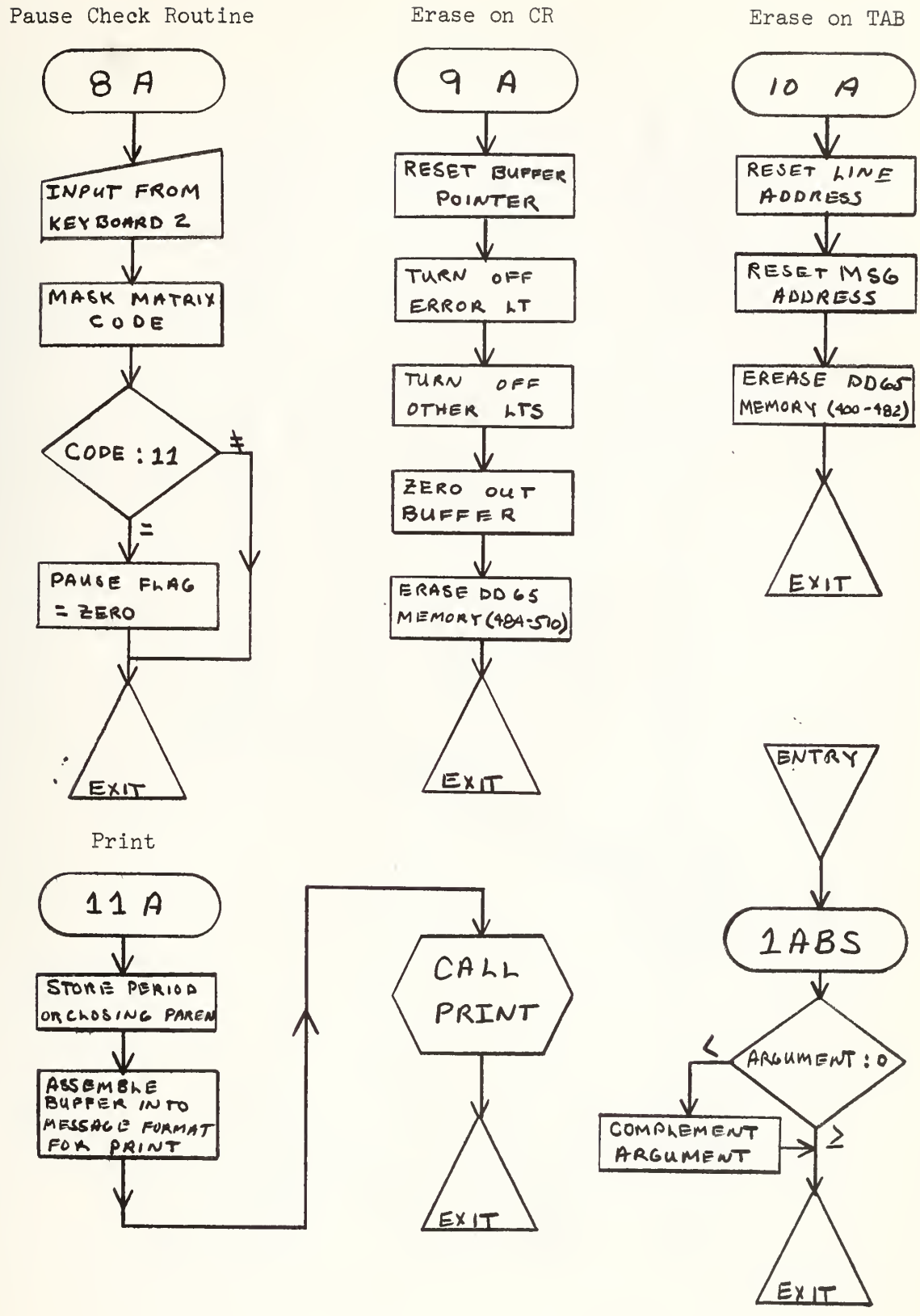

Pause Check Routine
8 A
INPUT FROM KEYBOARD 2
MASK MATRIX CODE
CODE : 11
≠
=
PAUSE FLAG = ZERO
EXIT
Erase on CR
9 A
RESET BUFFER POINTER
TURN OFF ERROR LT
TURN OFF OTHER LTS
ZERO OUT BUFFER
ERASE DD 65 MEMORY (484-510)
EXIT
Erase on TAB
10 A
RESET LINE ADDRESS
RESET MSG ADDRESS
EREASE DD65 MEMORY (400-482)
EXIT
Print
11 A
STORE PERIOD OR CLOSING PAREN
ASSEMBLE BUFFER INTO MESSAGE FORMAT FOR PRINT
CALL PRINT
EXIT
ENTRY
1ABS
ARGUMENT : 0
<
≥
COMPLEMENT ARGUMENT
EXIT

Figure I-4

Change Routine

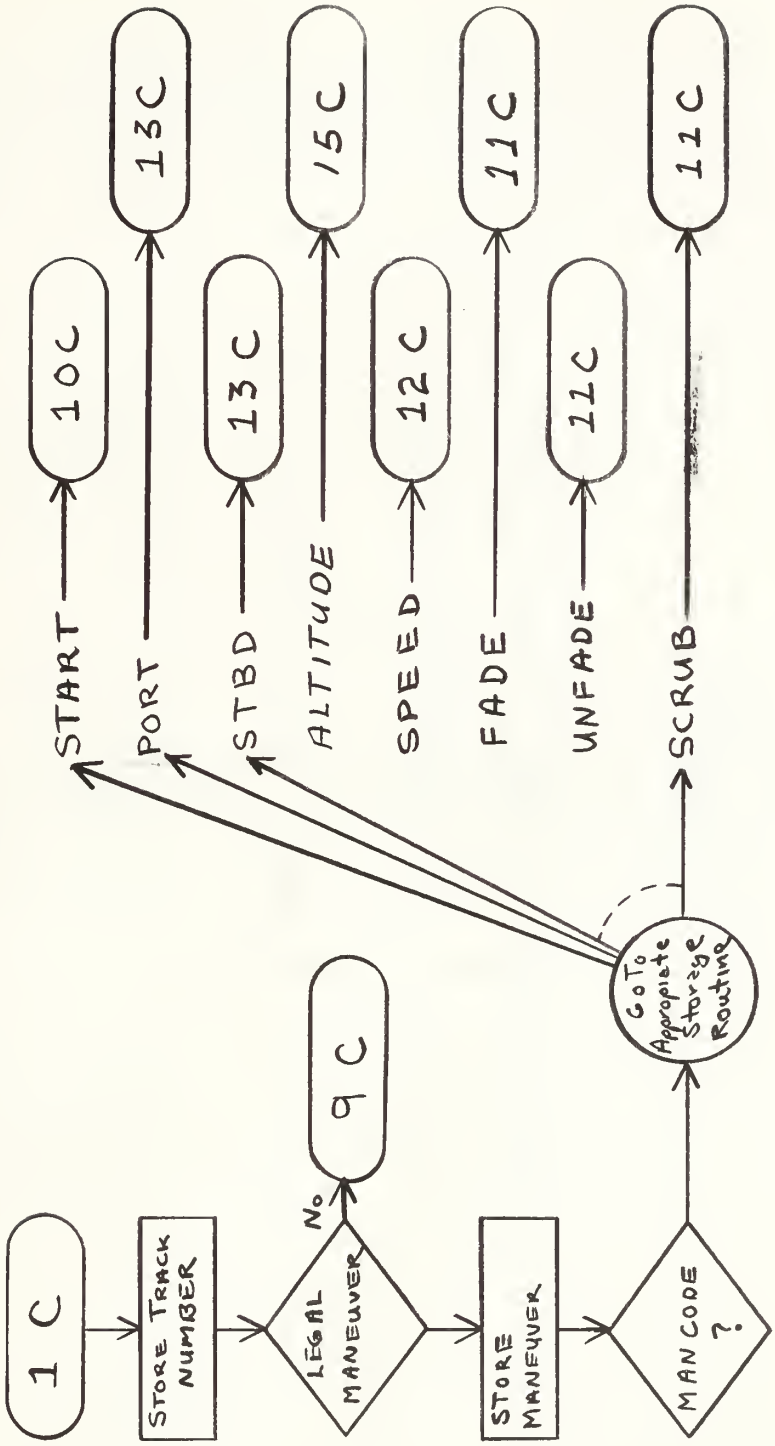


Figure I-5

Storage Routines

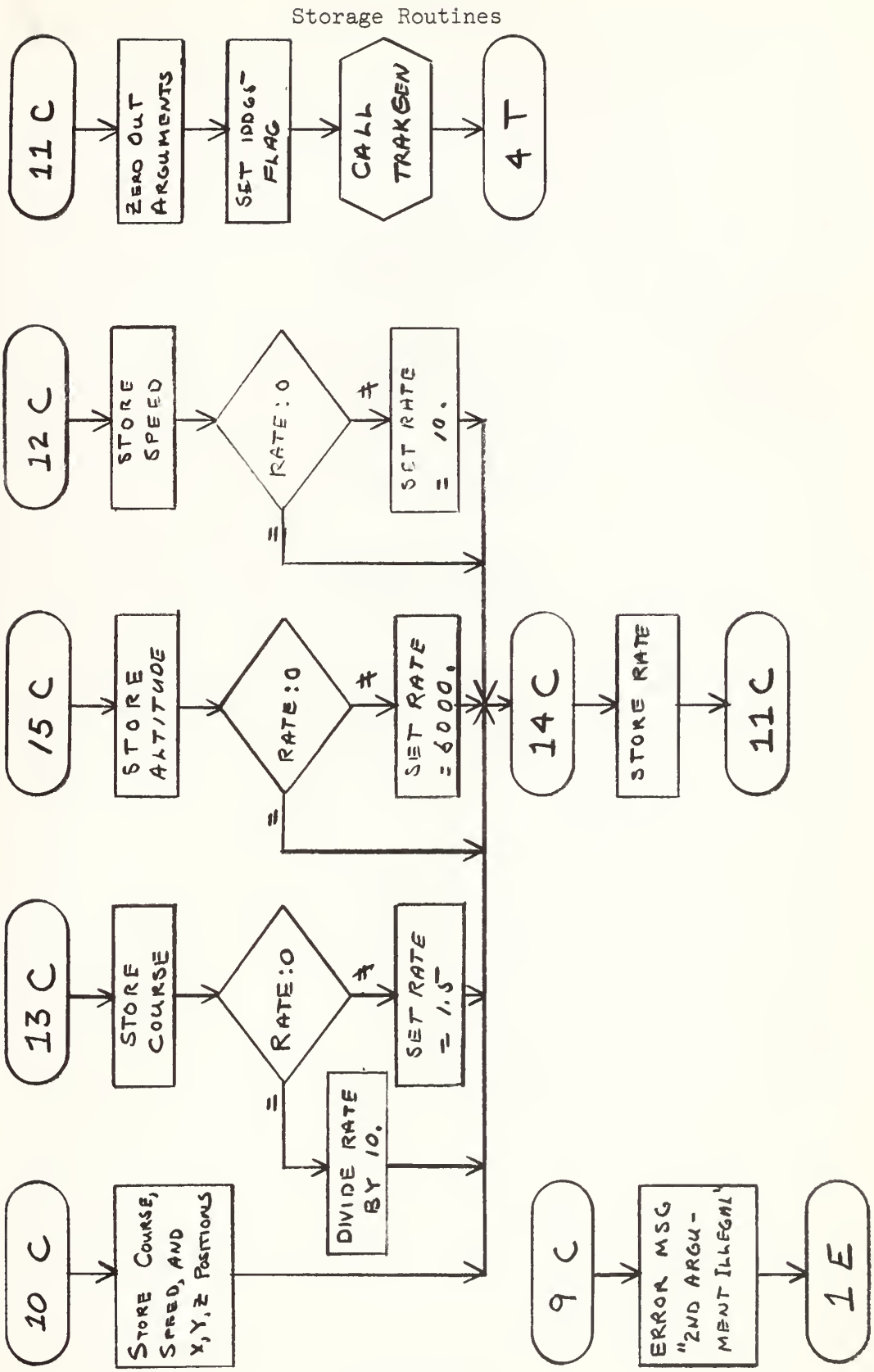


Figure I-6

Error Message Routine

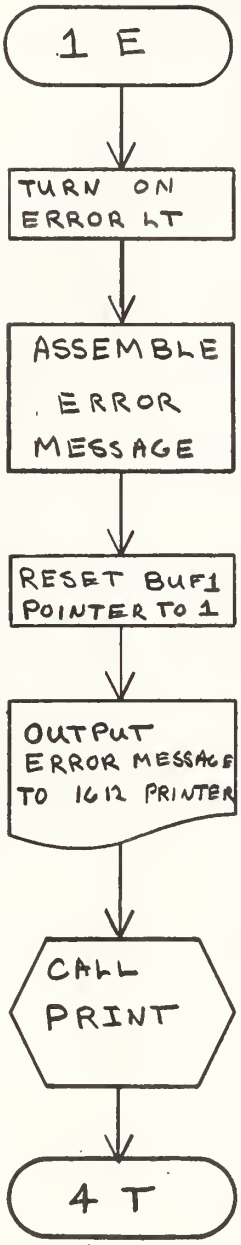


Figure I-7

Display Subprogram

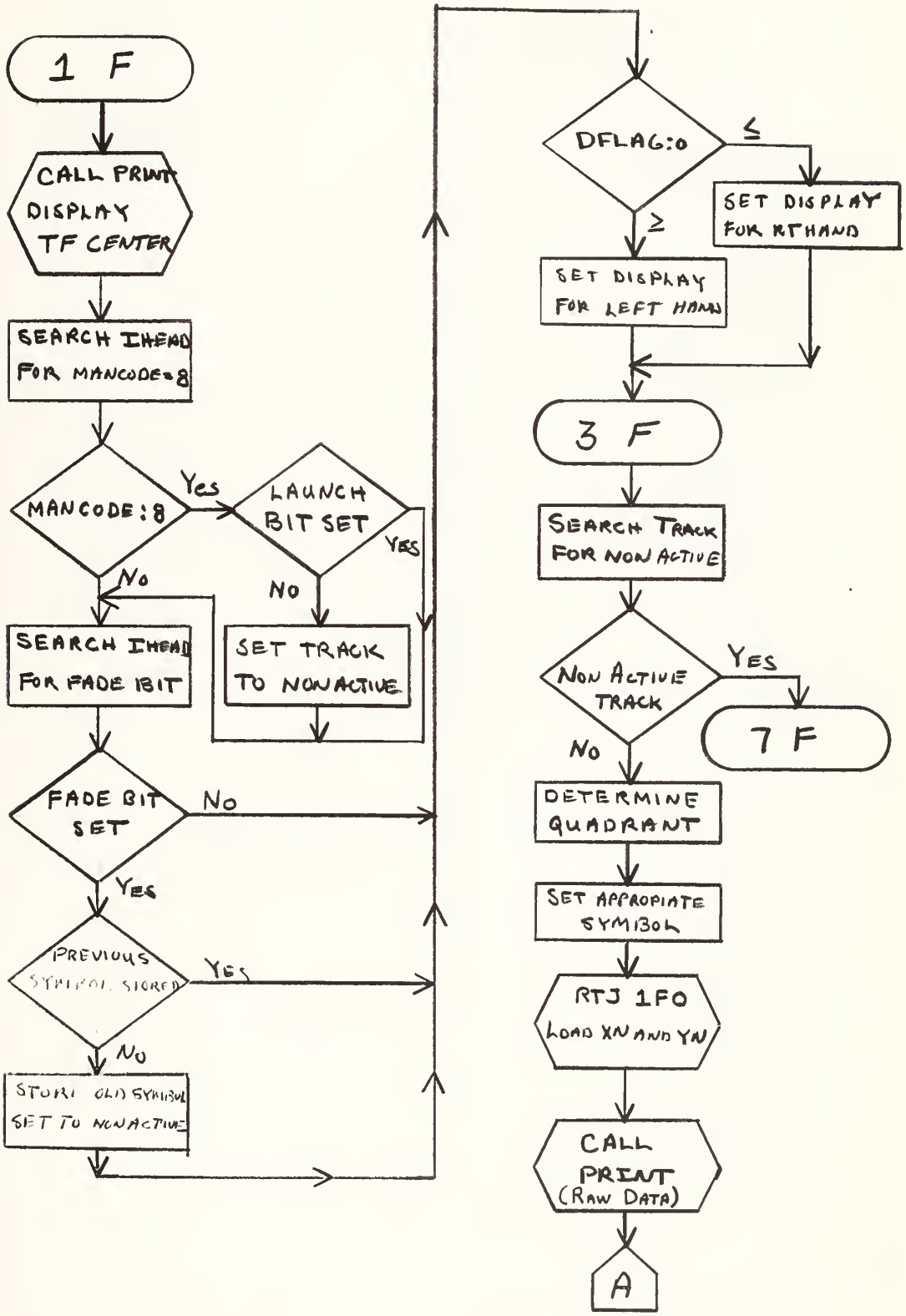


Figure I-8

Display Subprogram (cont)

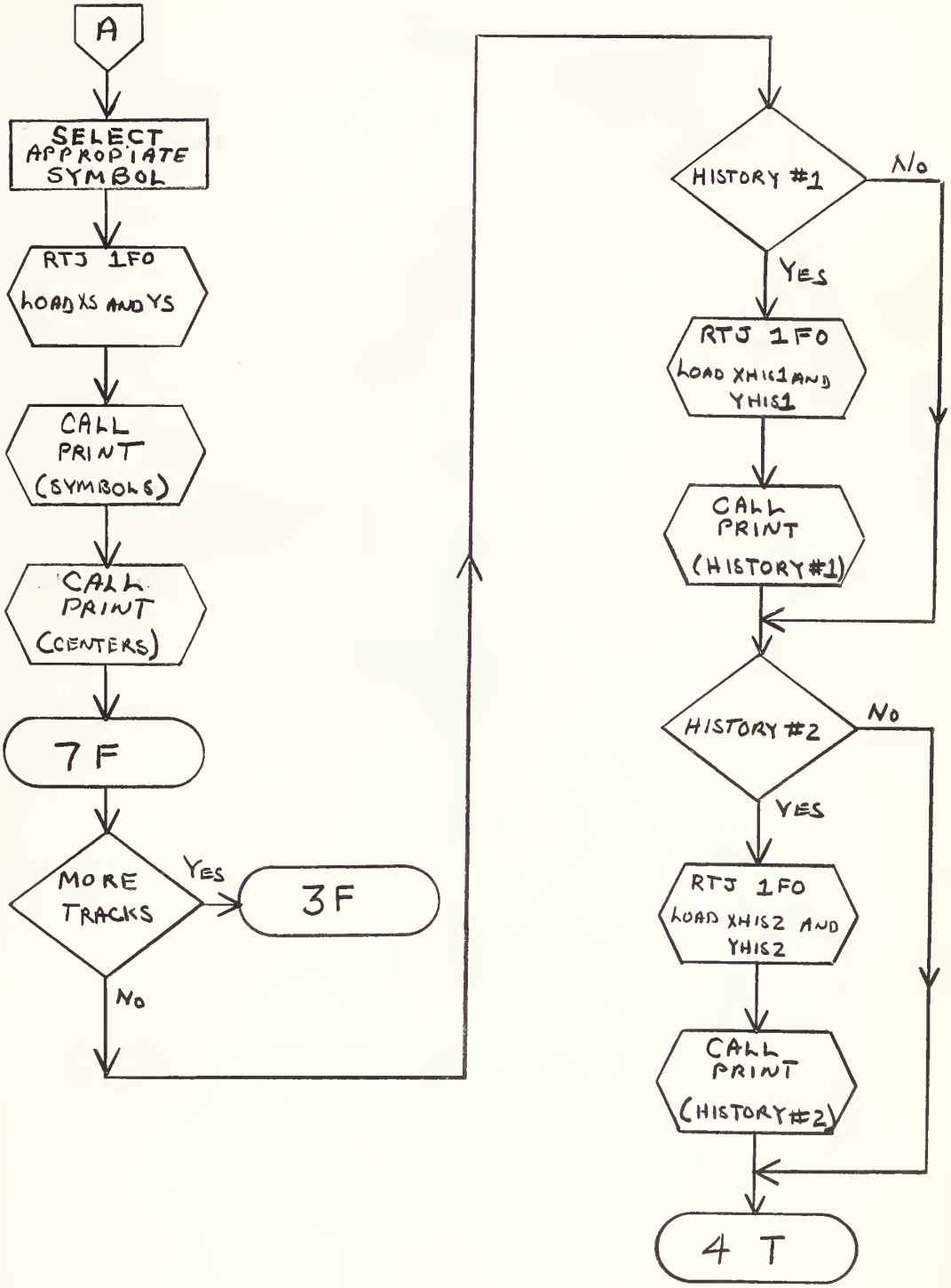


Figure I-9

Load X and Y Routine

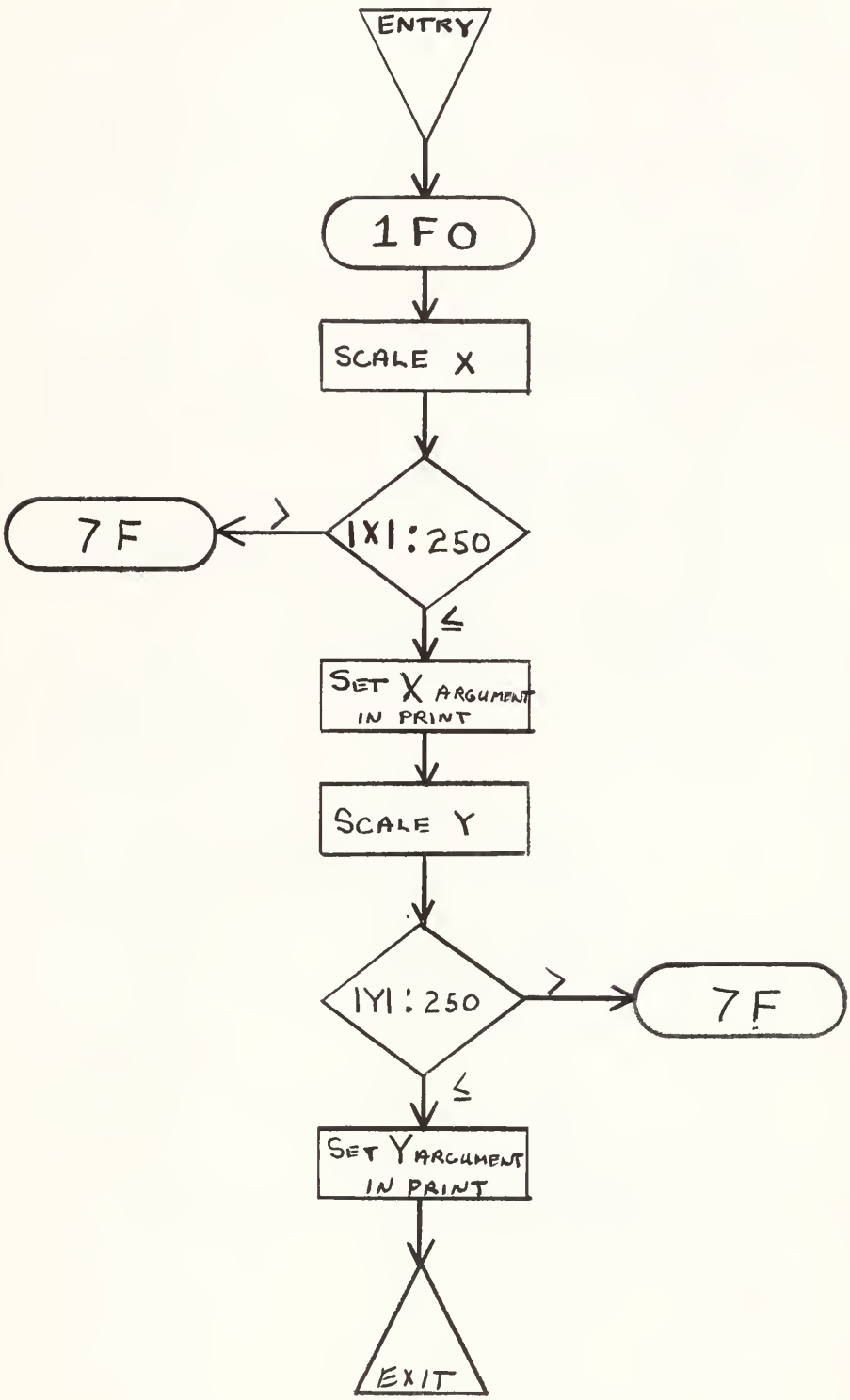


Figure I-10

Radar Processor Subprogram

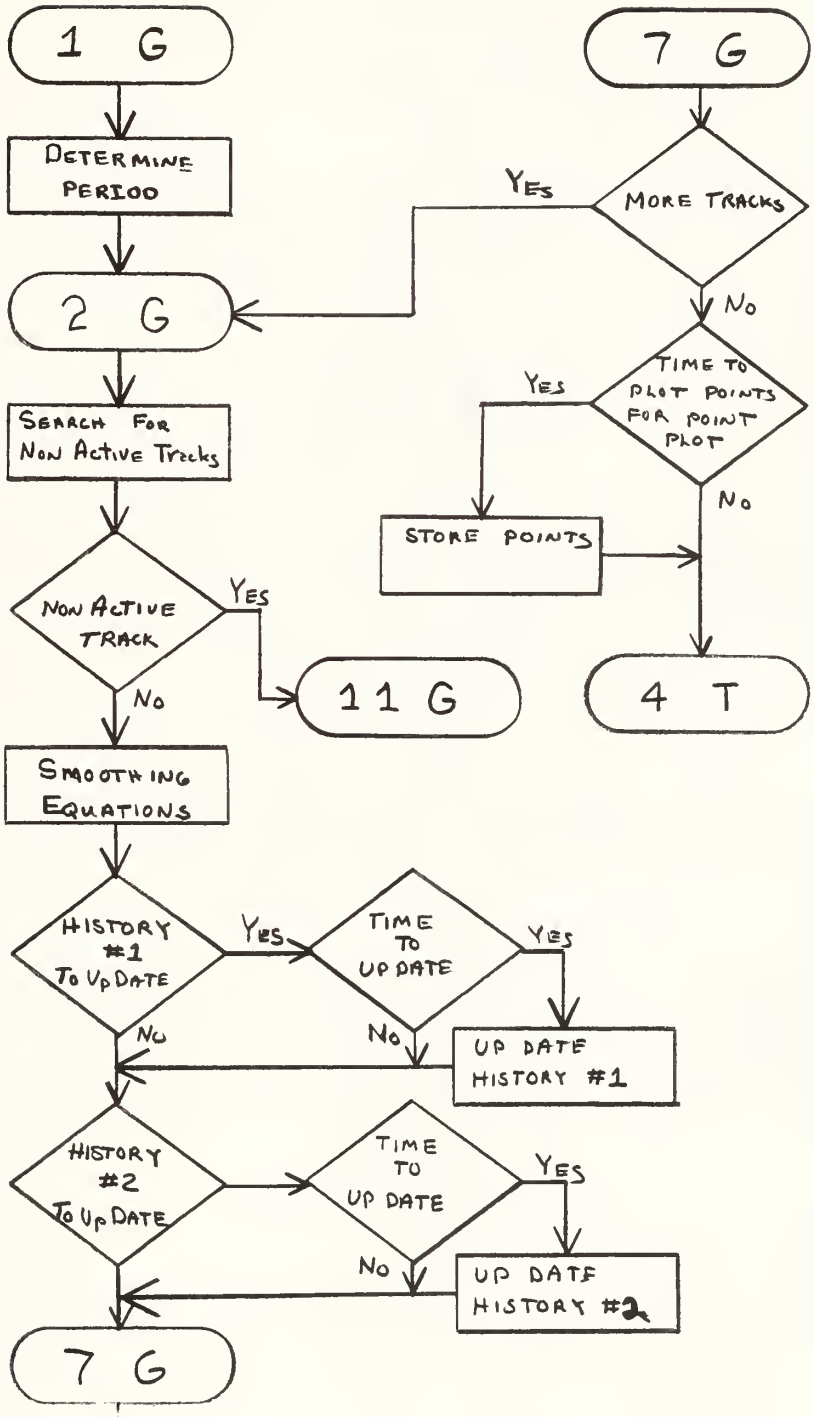


Figure I-11

Radar Processor Subprogram (cont)

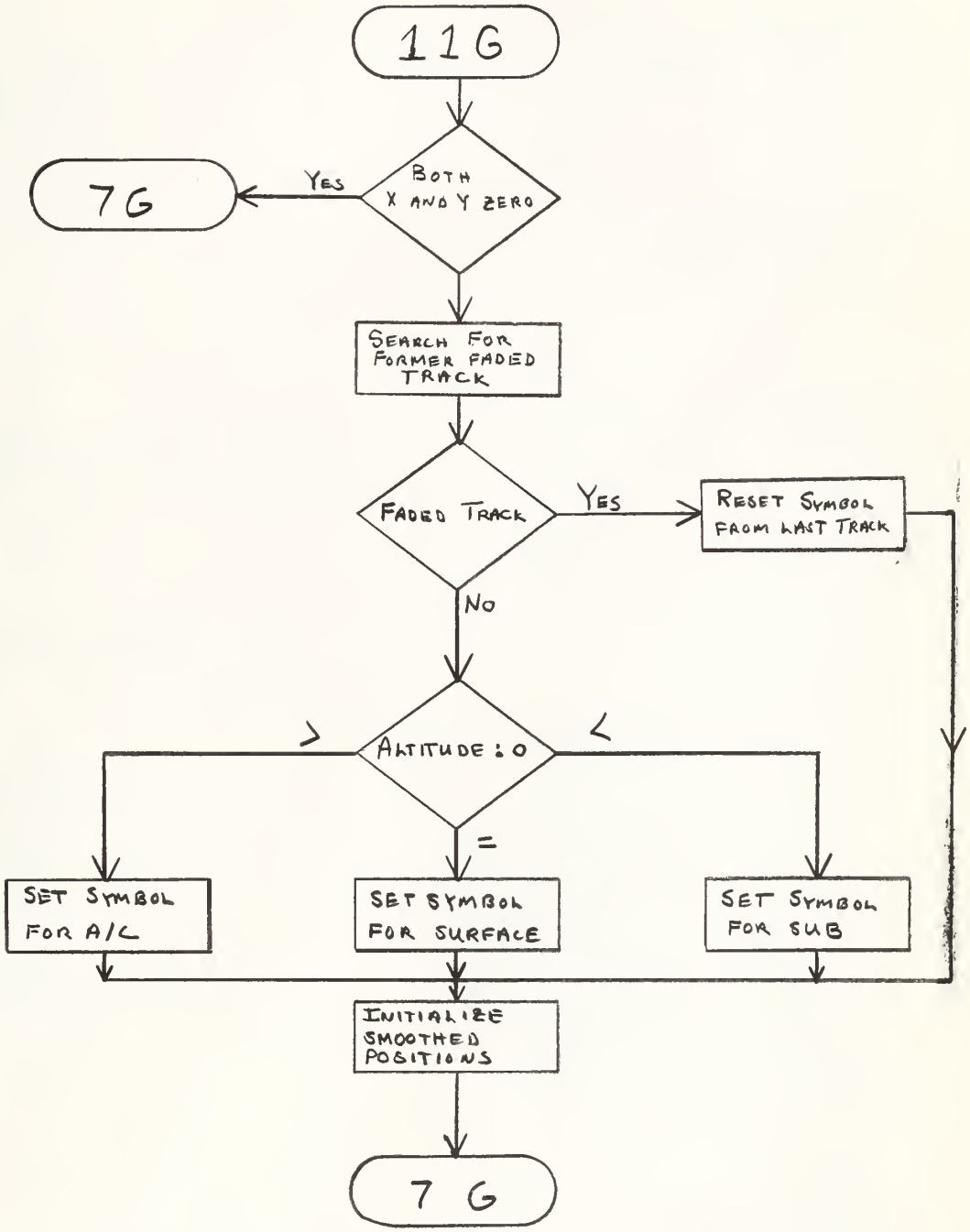


Figure I-12

Aircraft Control Subprogram

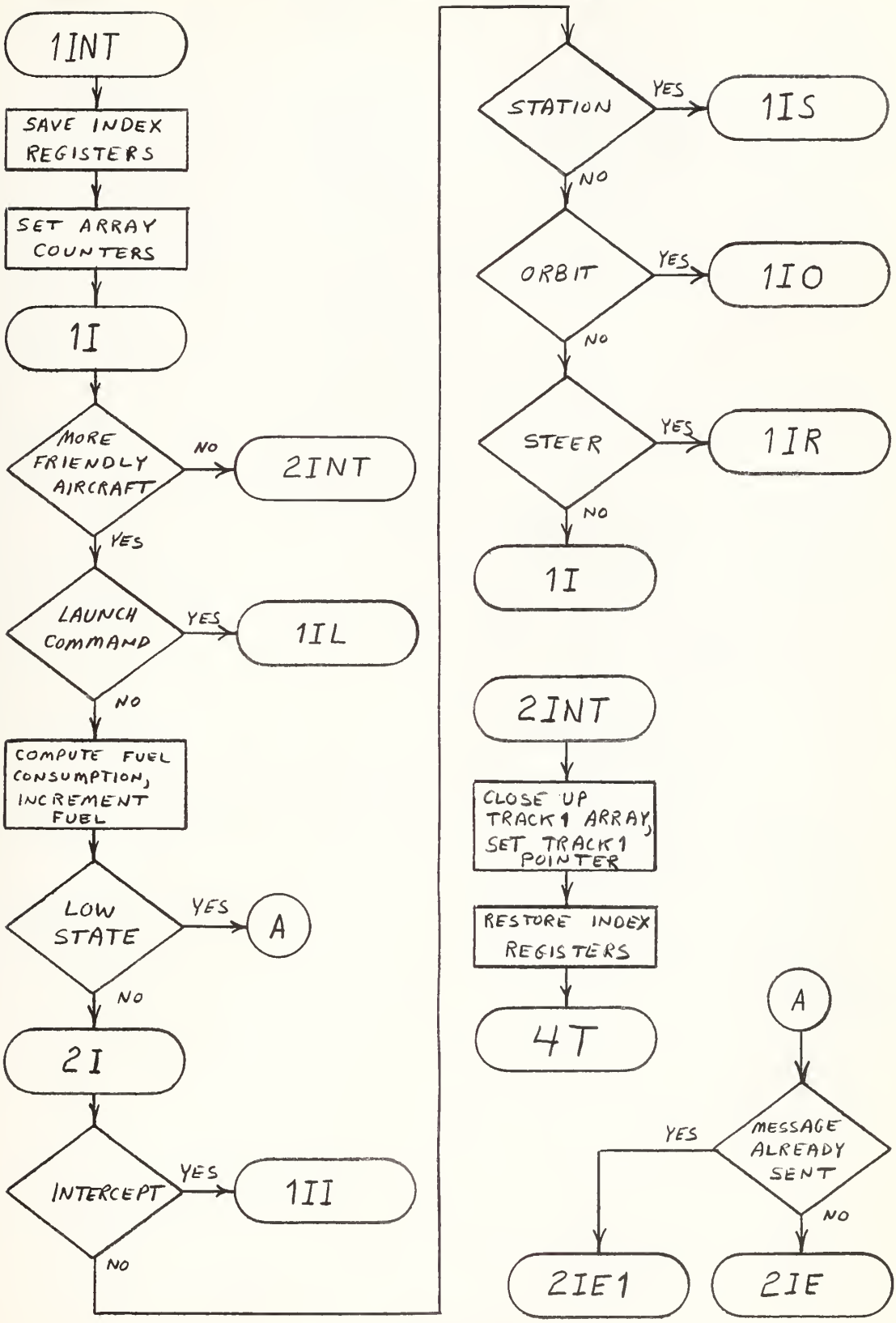


Figure I-13

Send Message Routine

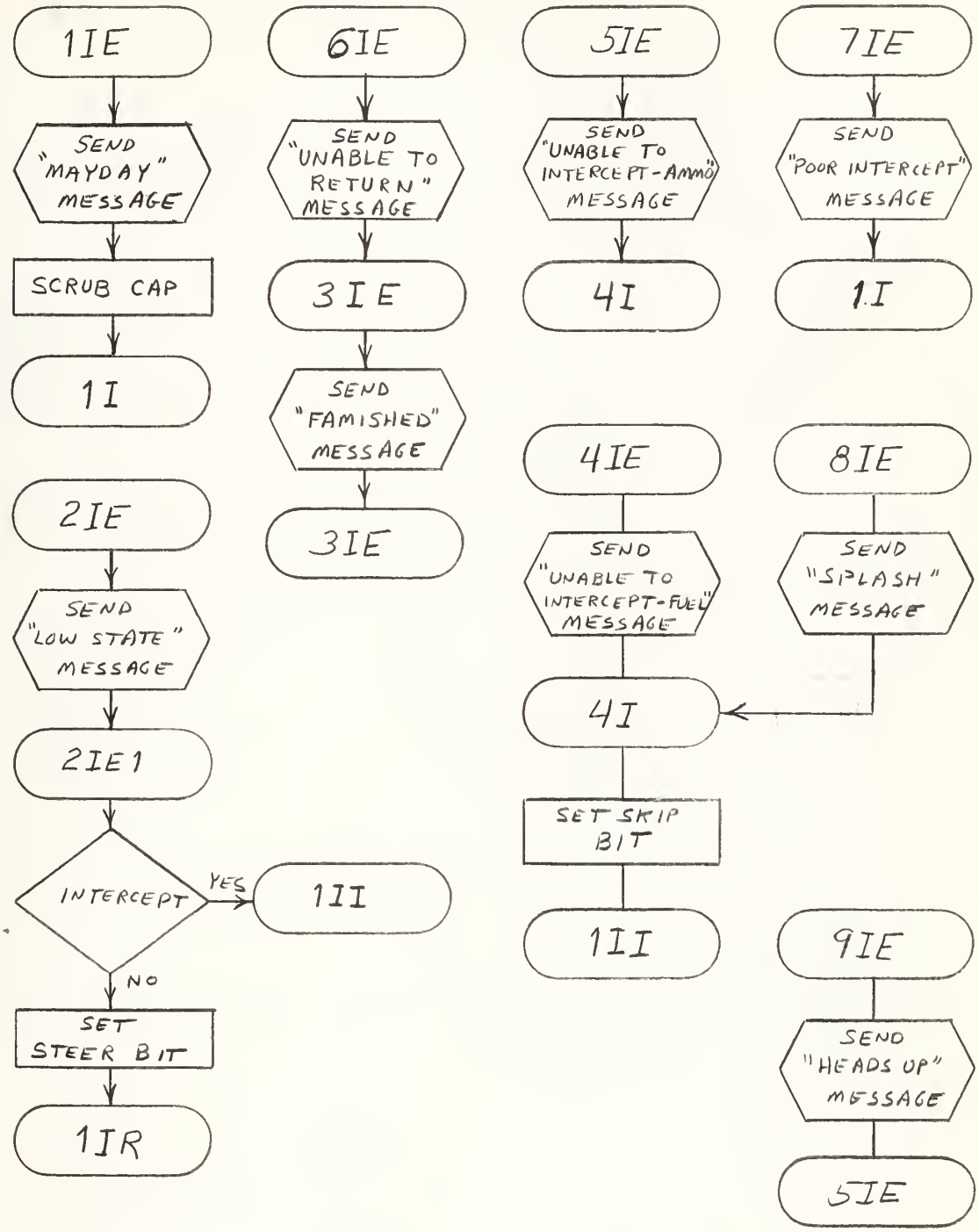


Figure I-14

Intercept and Skip Routines

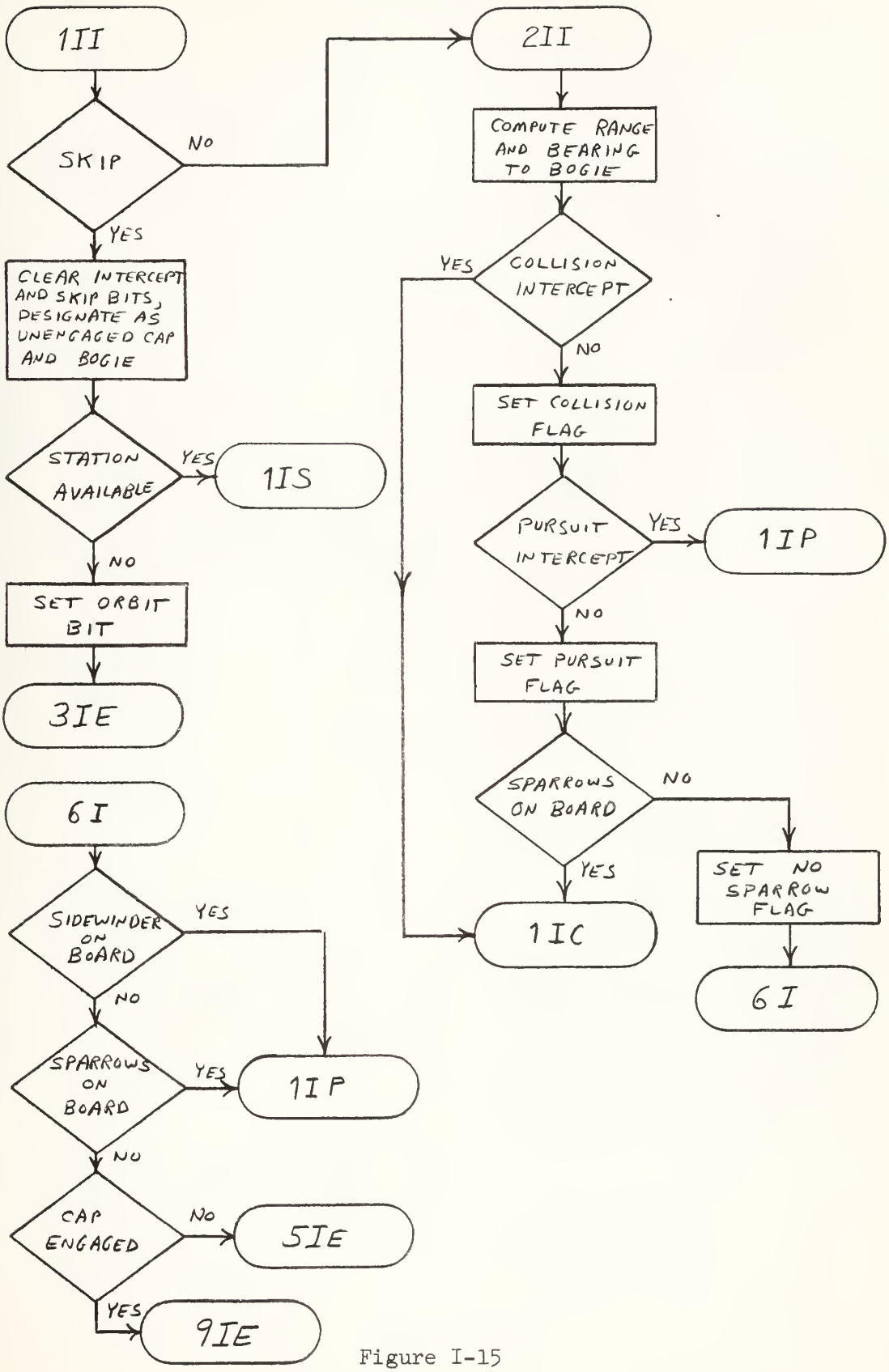


Figure I-15

Collision Intercept and Station Routines

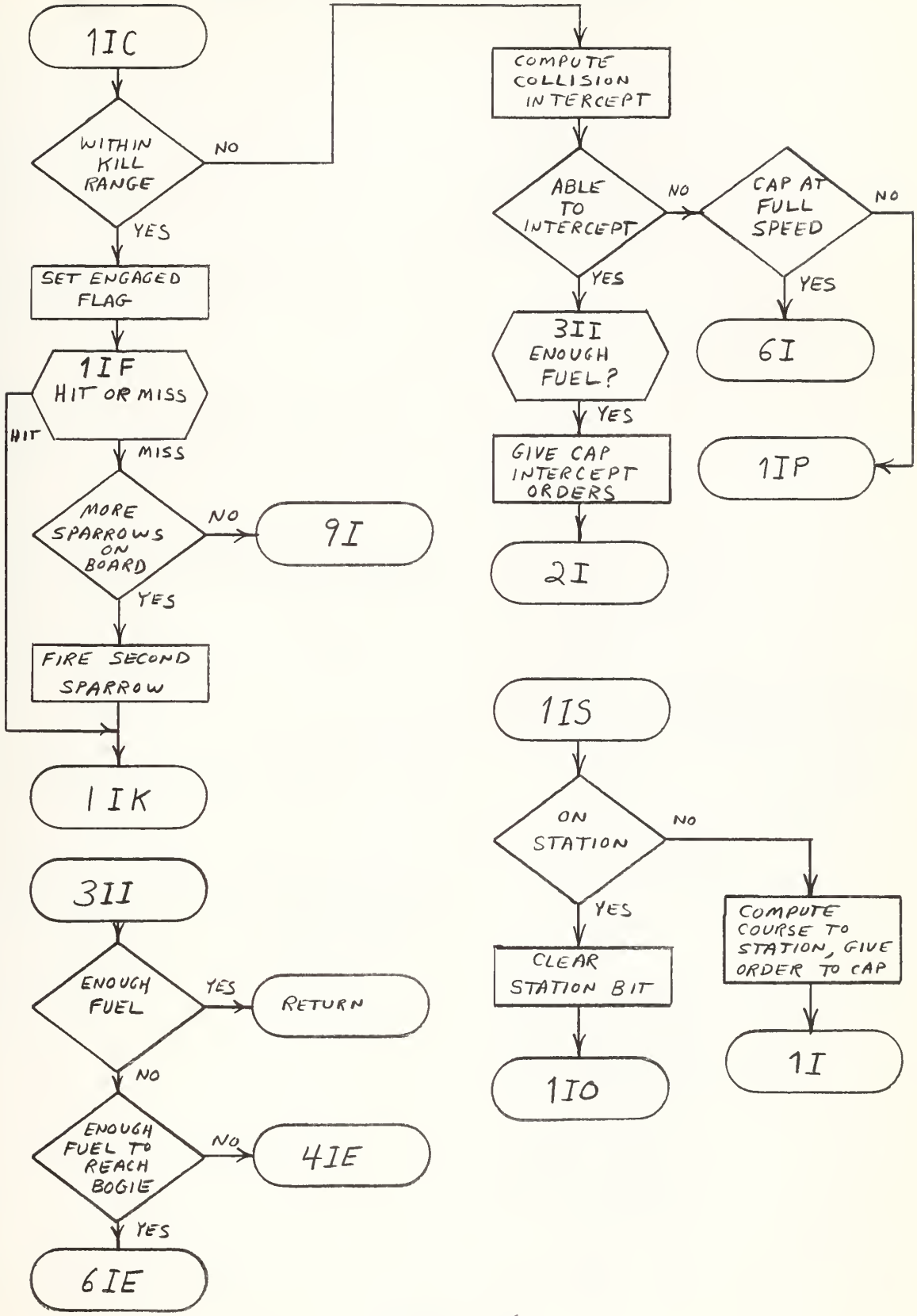


Figure I-16

Pursuit Intercept and Steer Routines

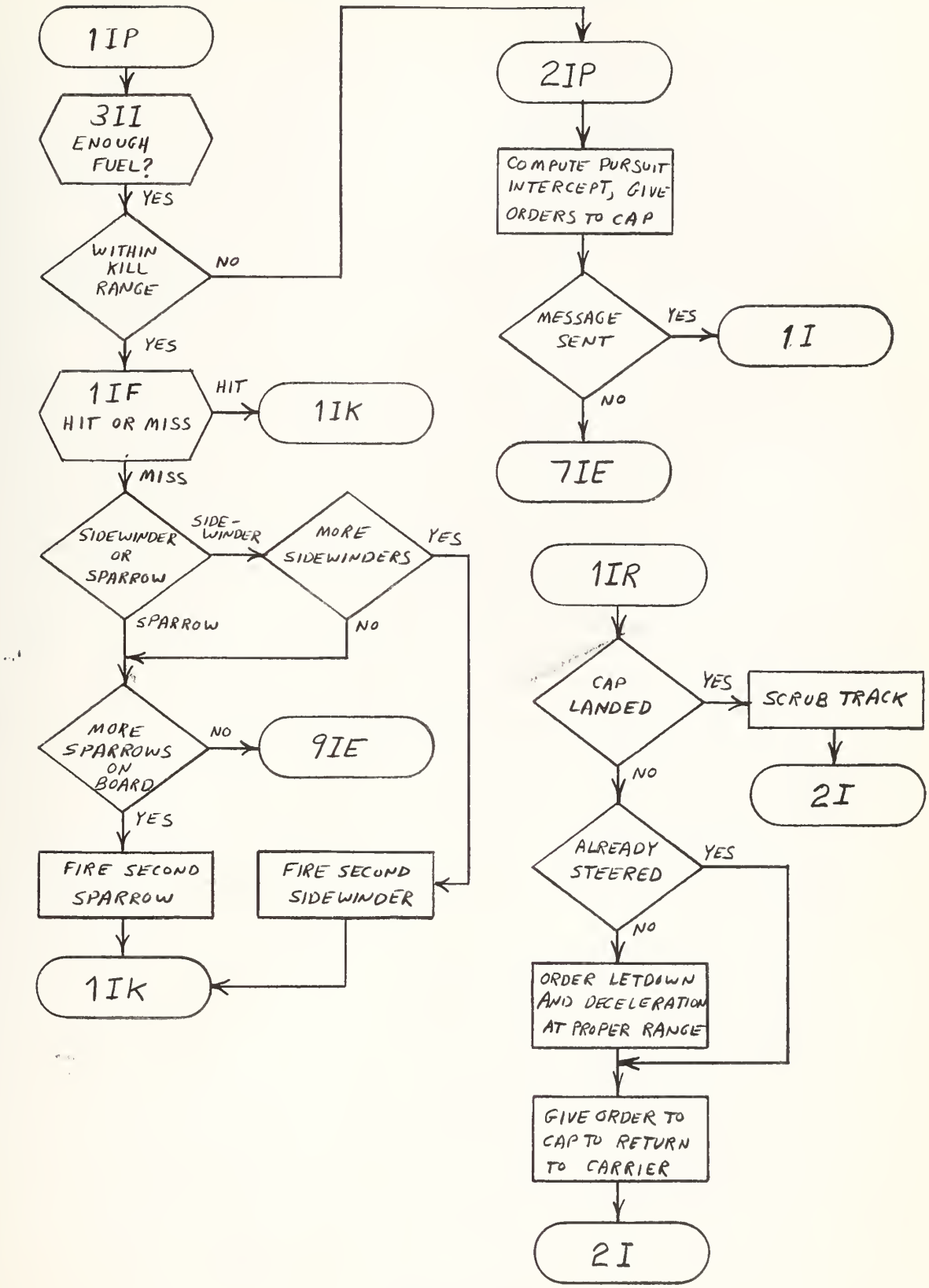


Figure I-17

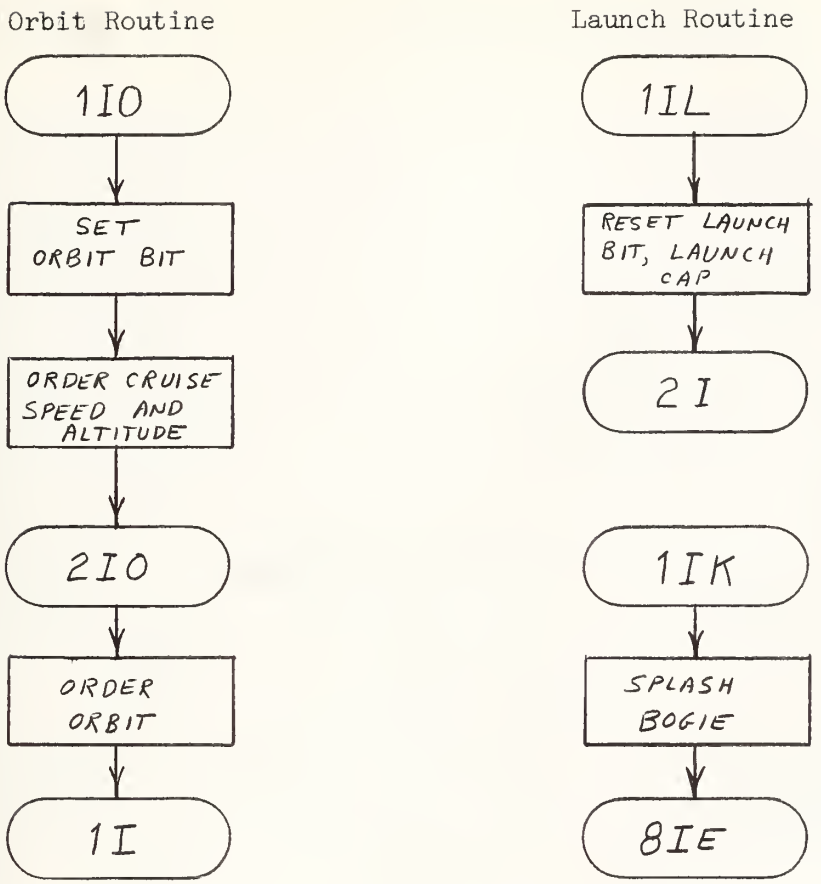

Orbit Routine
1IO
SET ORBIT BIT
ORDER CRUISE SPEED AND ALTITUDE
2IO
ORDER ORBIT
1I
Launch Routine
1IL
RESET LAUNCH BIT, LAUNCH CAP
2I
1IK
SPLASH BOGIE
8IE

Figure I-18

Designate Track Routine

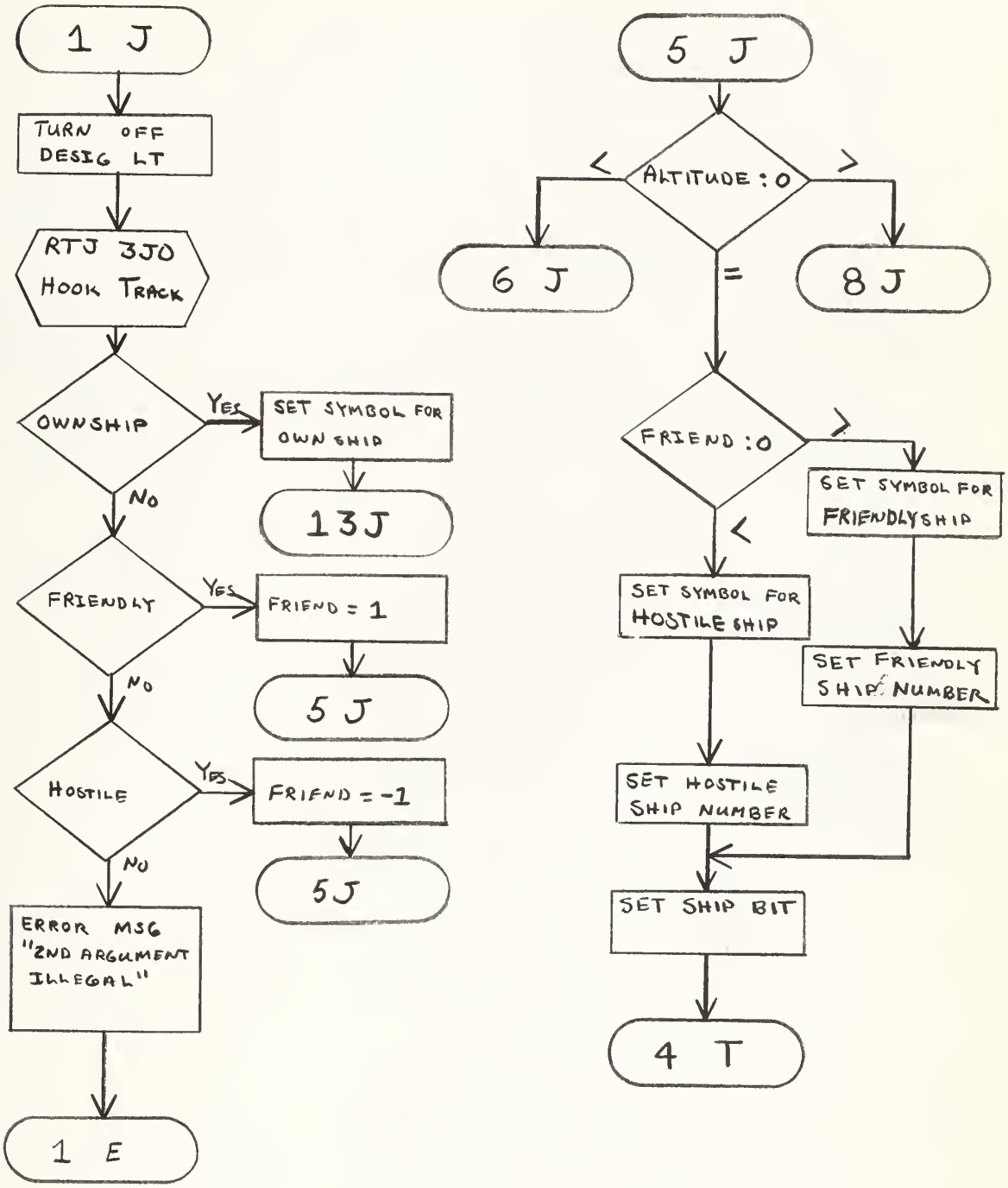


Figure I-19

Designate Track Routine (cont)

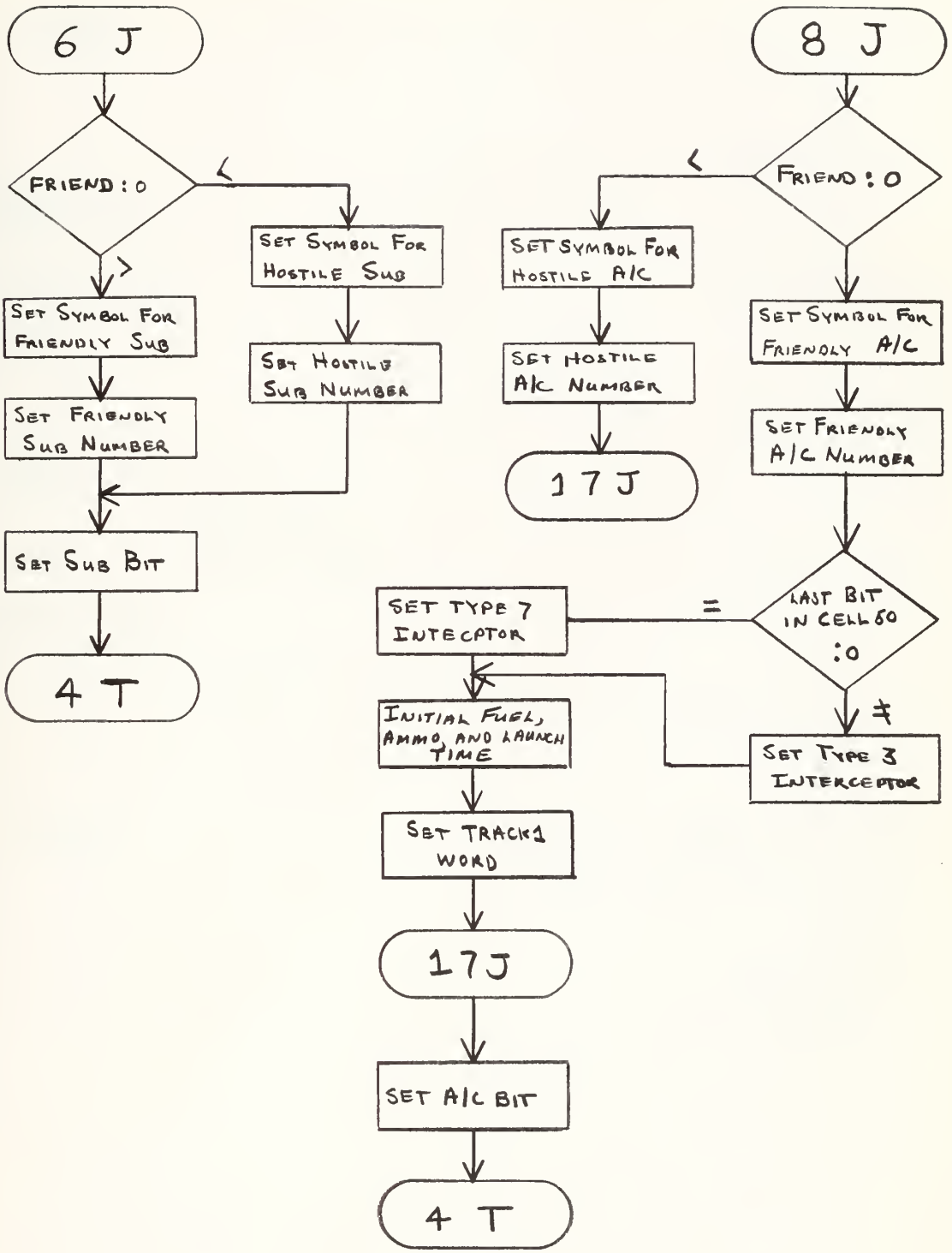


Figure I-20

Hook Track Routine

Keyboard Command Subprogram

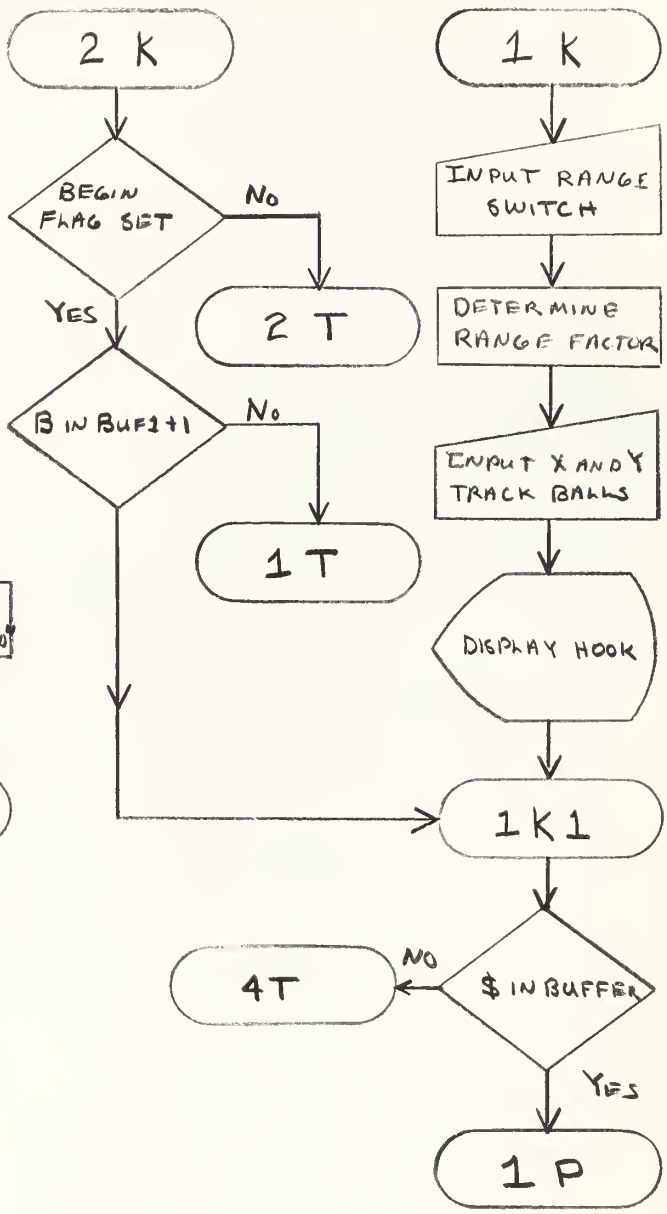


Figure I-21

History Routine

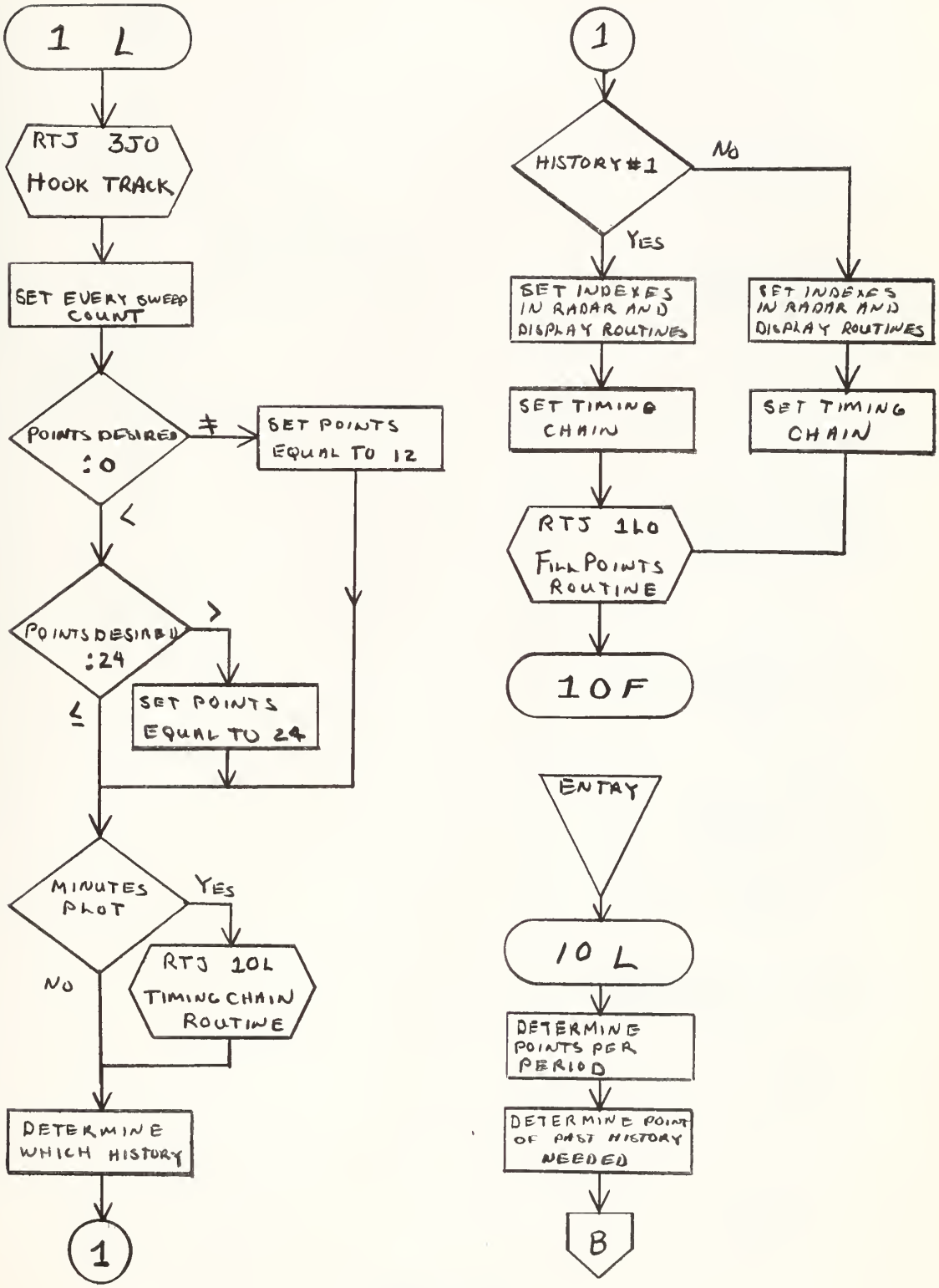


Figure I-22

History Routine (cont)

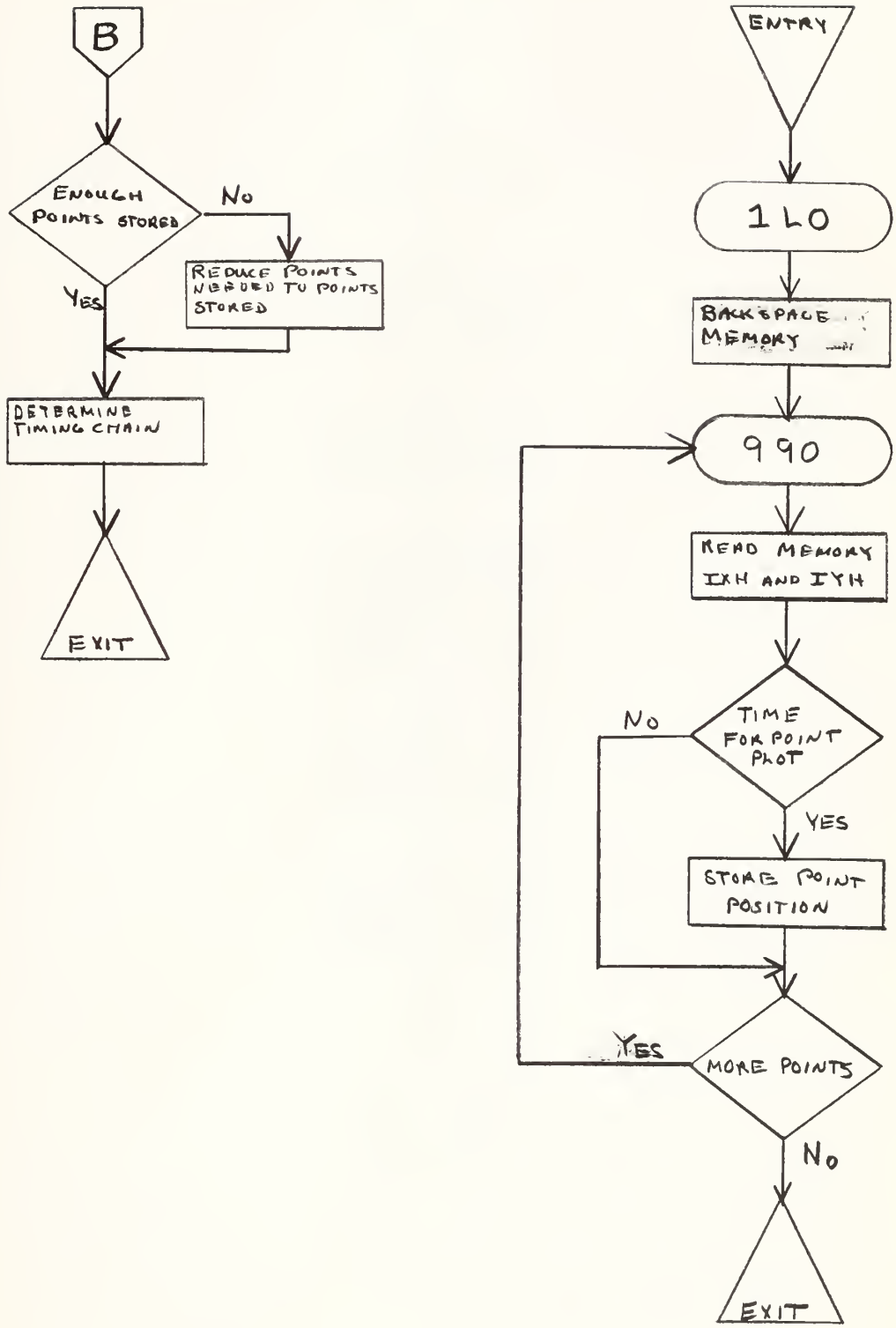


Figure I-23

Erase Routine

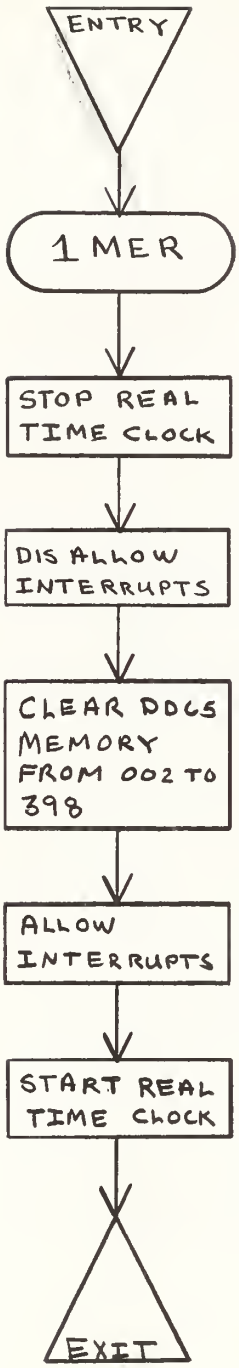
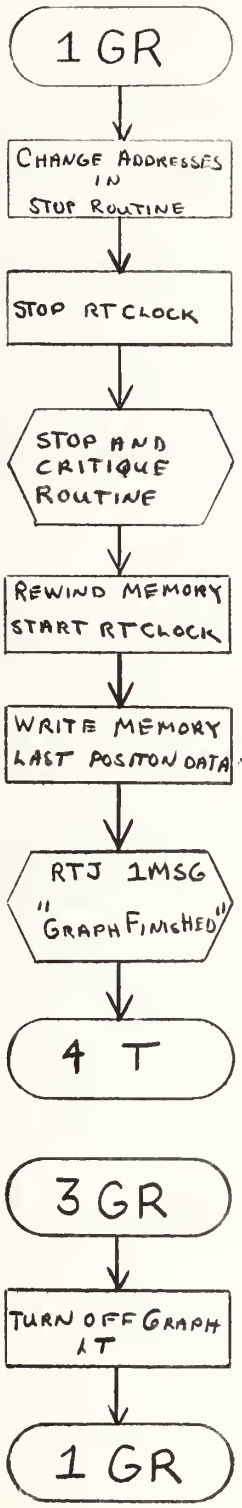
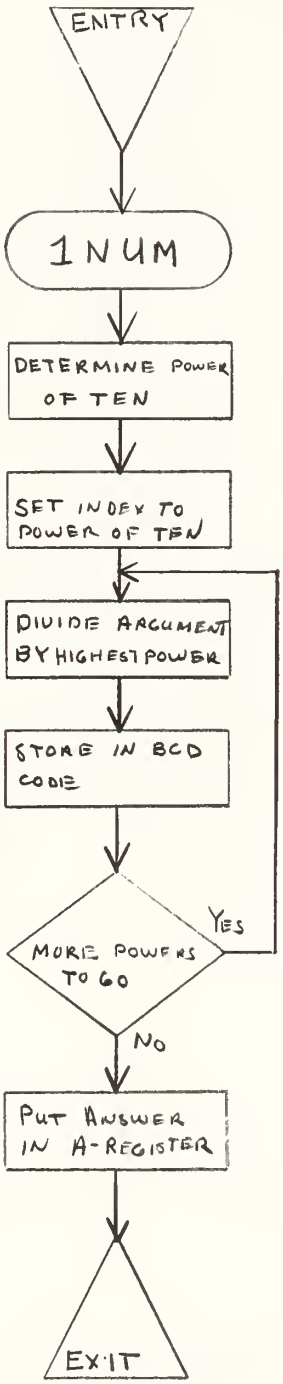


Figure I-24

Graph Subprogram



Octal to BCD Converter



Graph Title Update

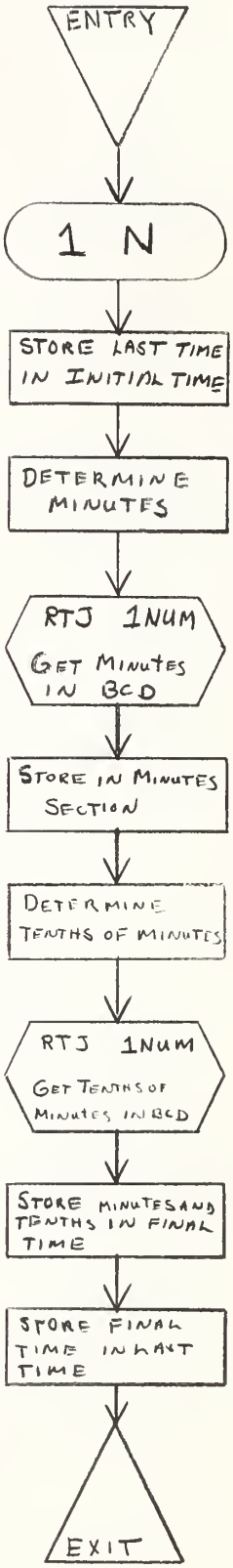


Figure I-25

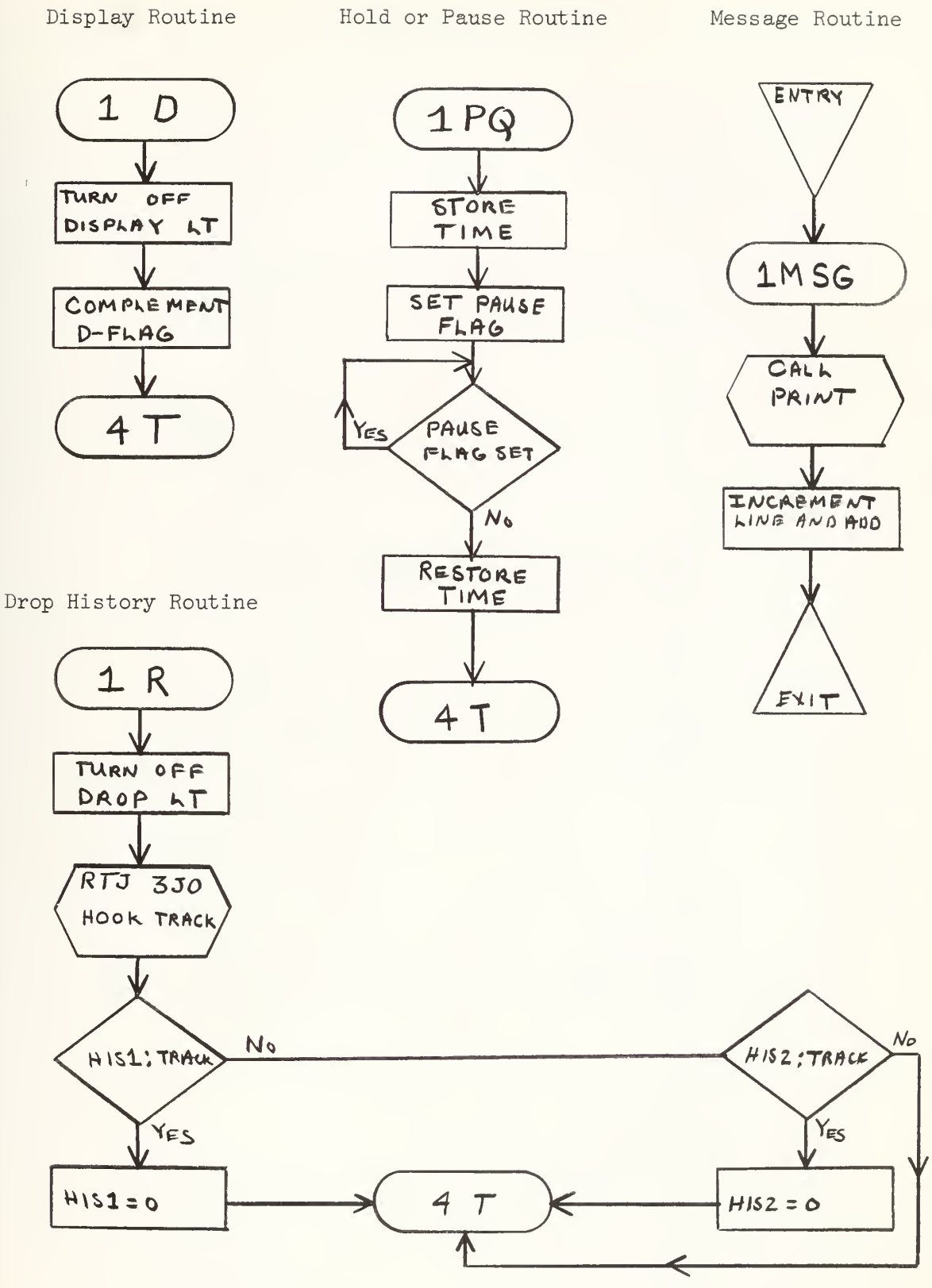

Display Routine
1 D
TURN OFF DISPLAY LT
COMPLEMENT D-FLAG
4 T
Hold or Pause Routine
1PQ
STORE TIME
SET PAUSE FLAG
PAUSE FLAG SET
YES
NO
RESTORE TIME
4 T
Message Routine
ENTRY
1MSG
CALL PRINT
INCREMENT LINE AND ADD
EXIT
Drop History Routine
1 R
TURN OFF DROP LT
RTJ 3J0 HOOK TRACK
HIS1; TRACK
NO
YES
HIS1 = 0
4 T
HIS2; TRACK
NO
YES
HIS2 = 0

Figure I-26

Program Control Routine

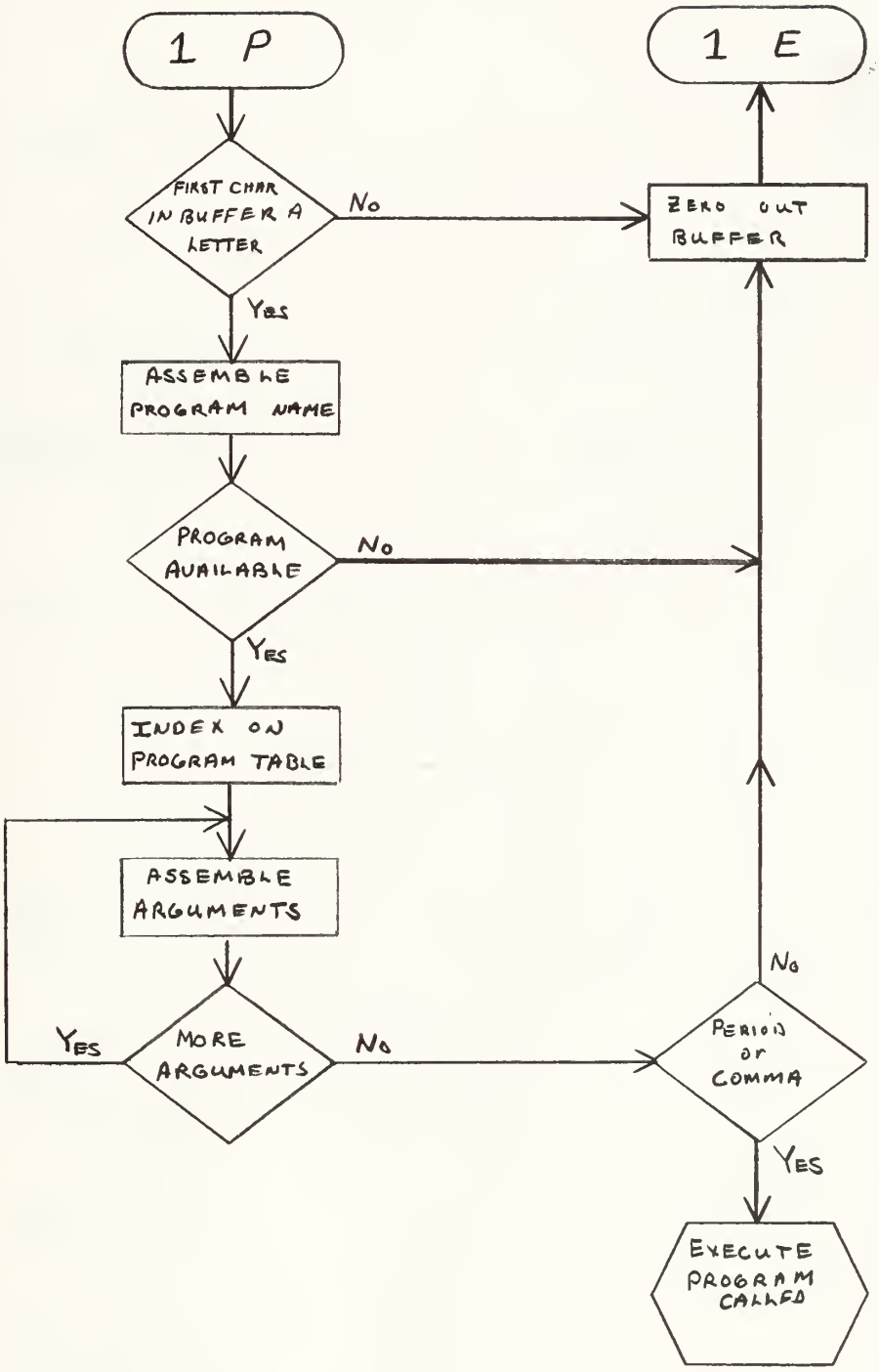


Figure I-27

Intercept Command Routine

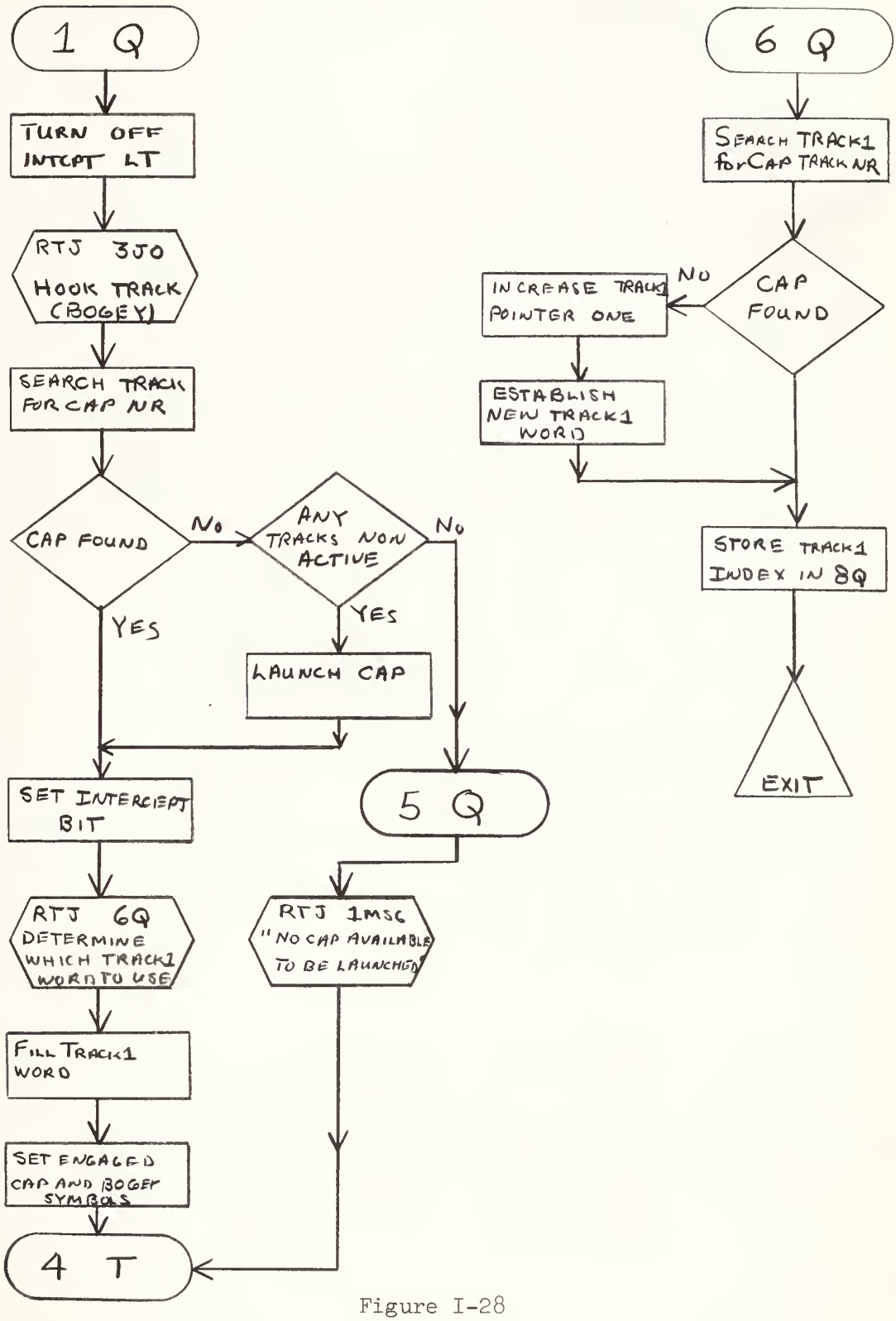


Figure I-28

Stop and Critique Routine

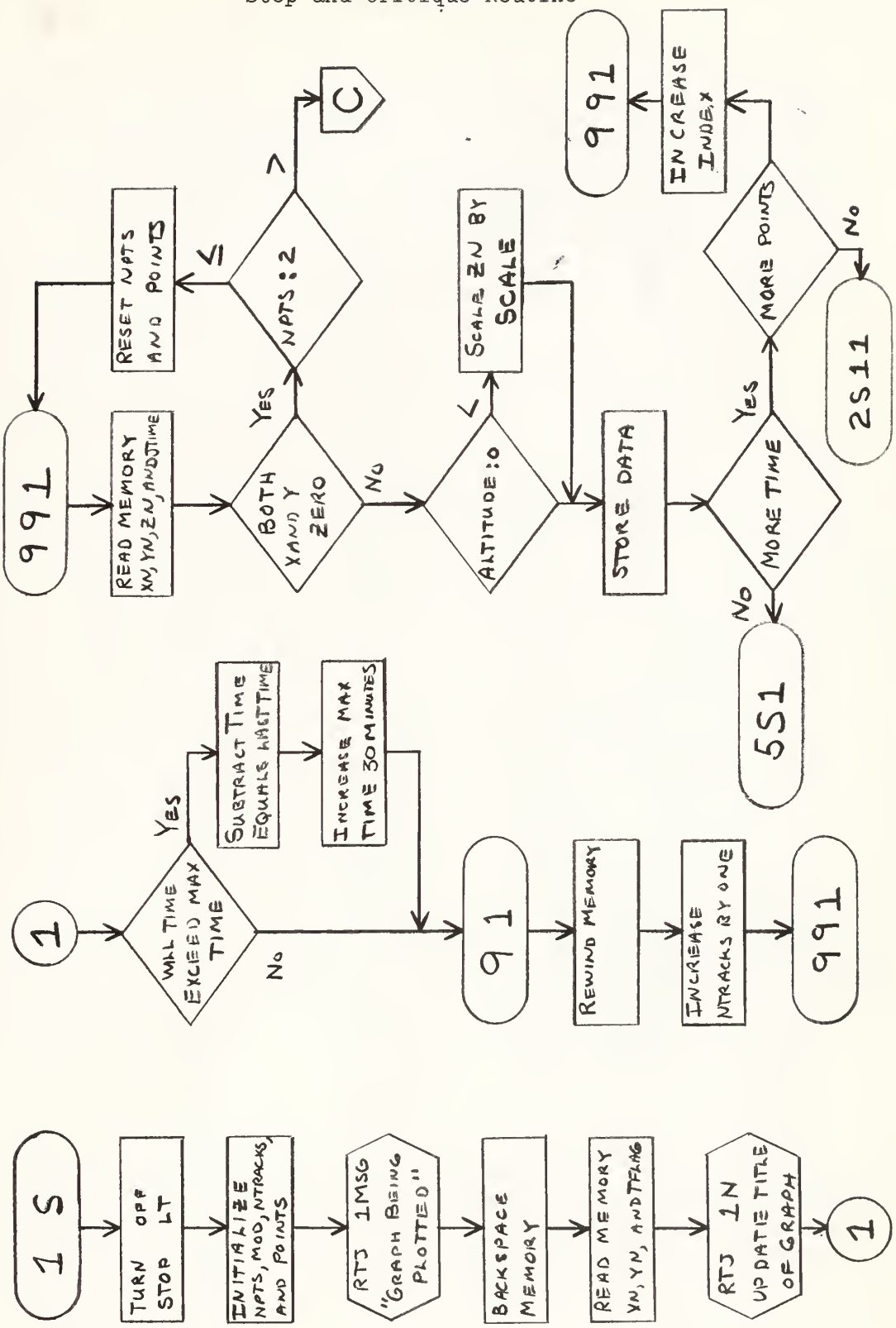


Figure I-29

Stop and Critique Routine (cont)

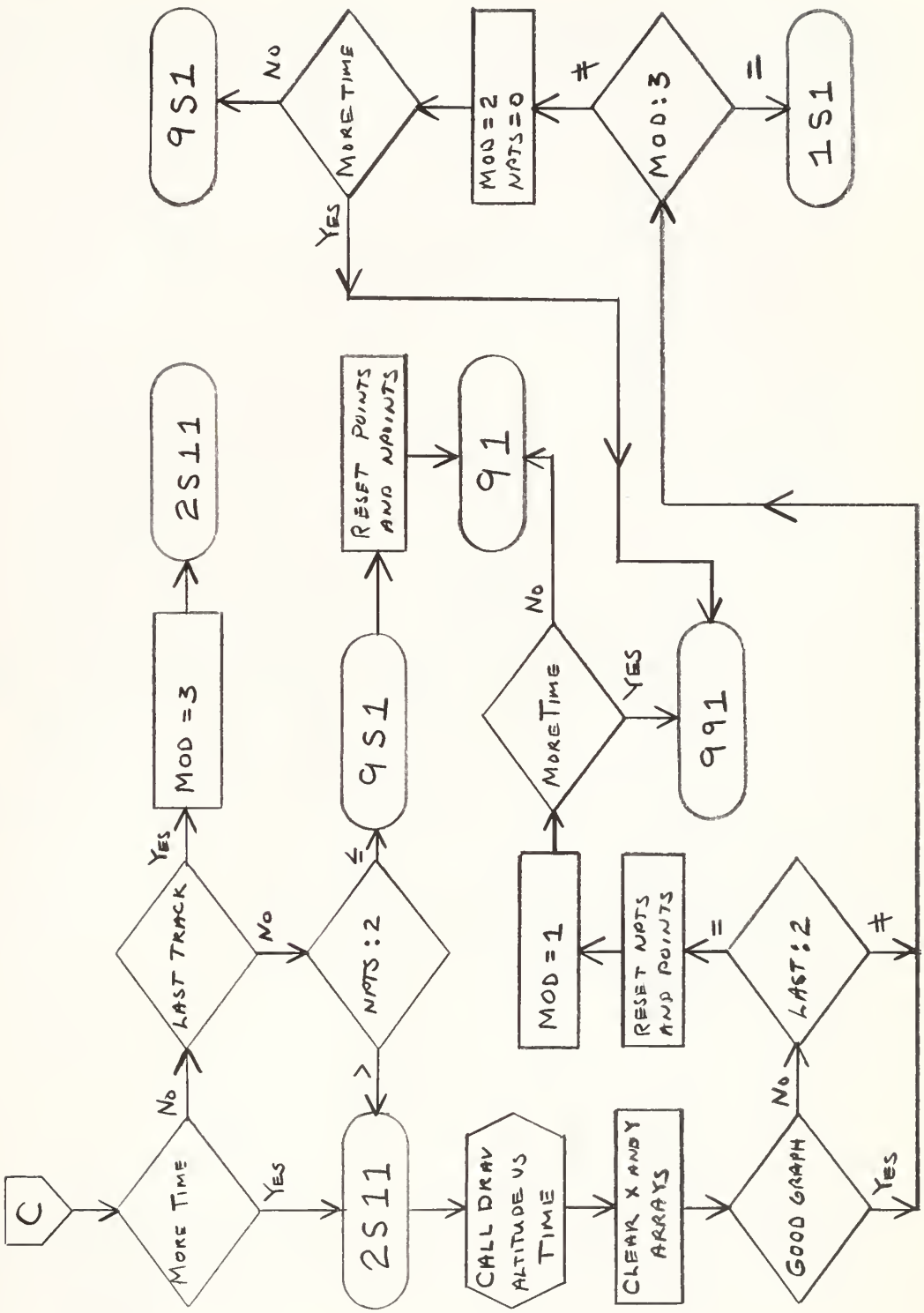


Figure I-30

Stop and Critique Routine (cont)

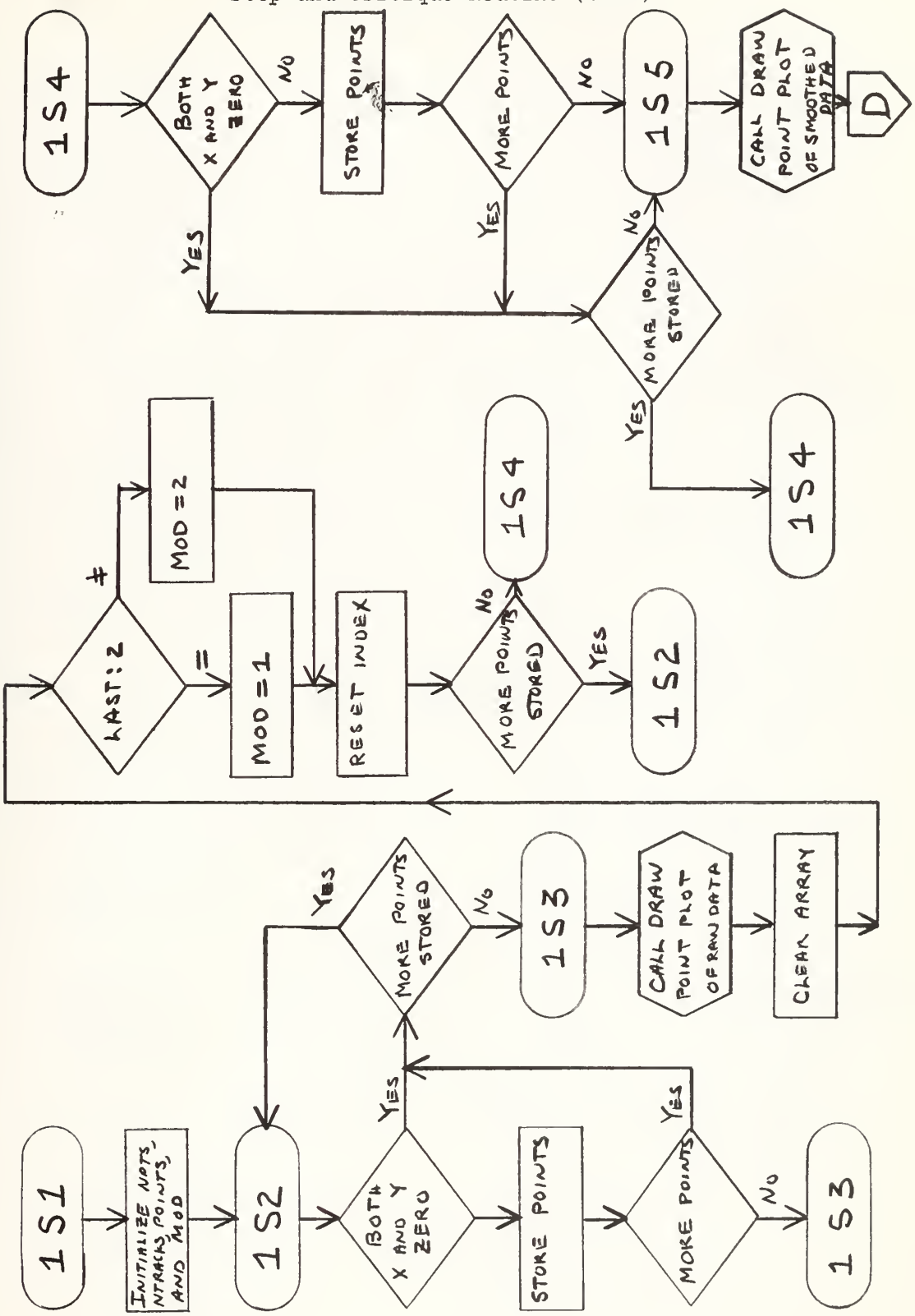


Figure I-31

Stop and Critique Routine (cont)

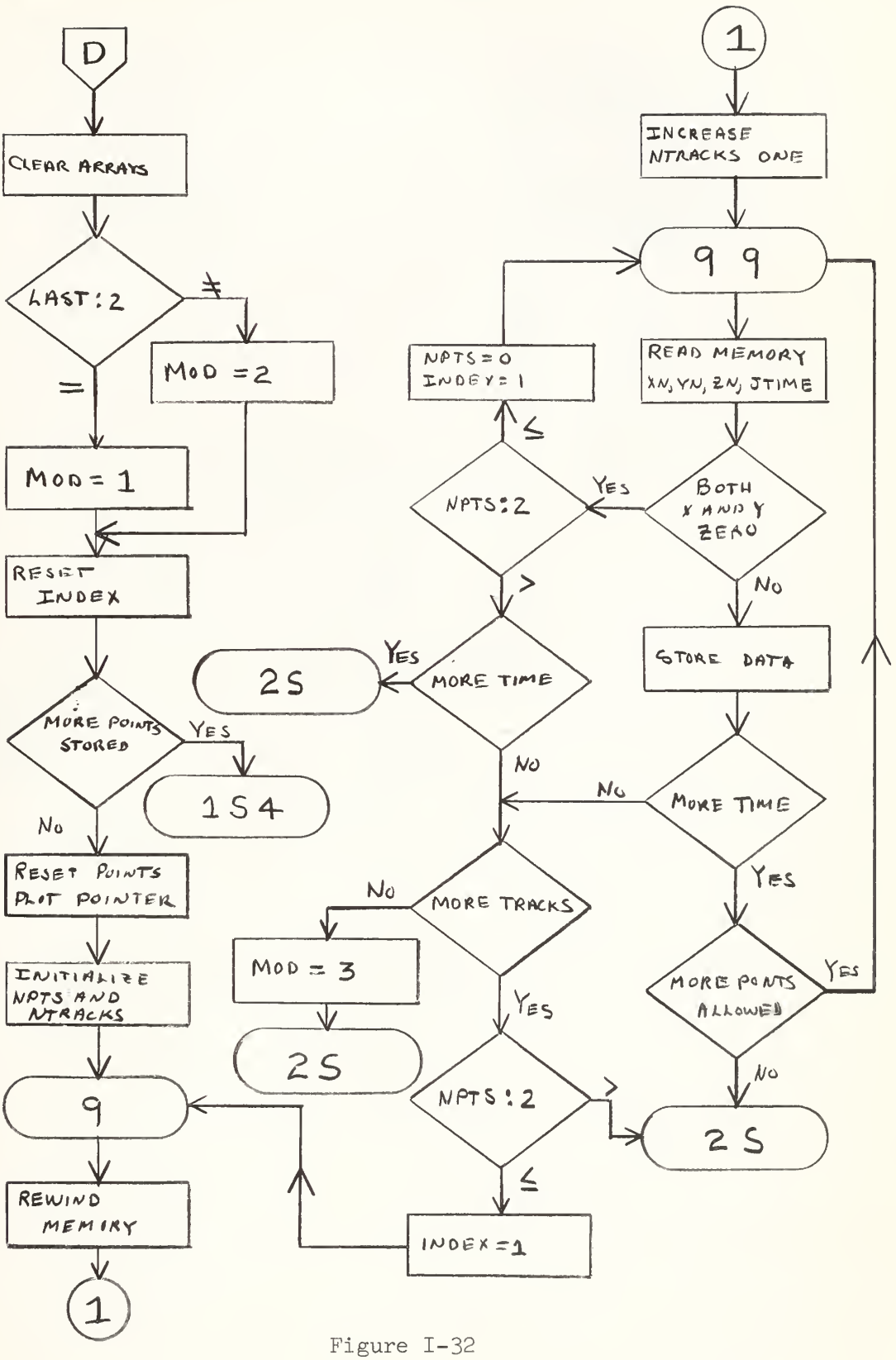


Figure I-32

Stop and Critique Routine (cont)

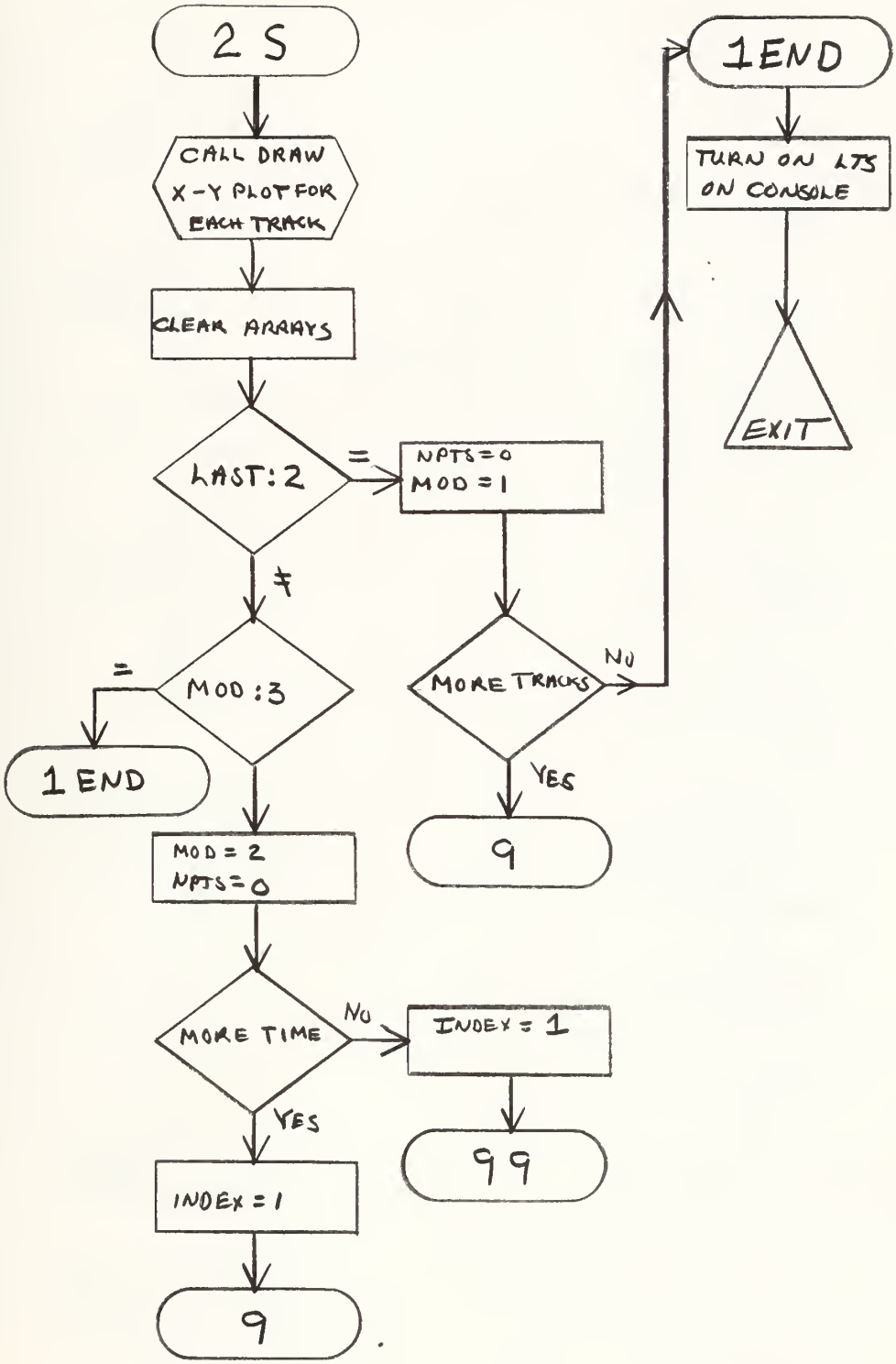
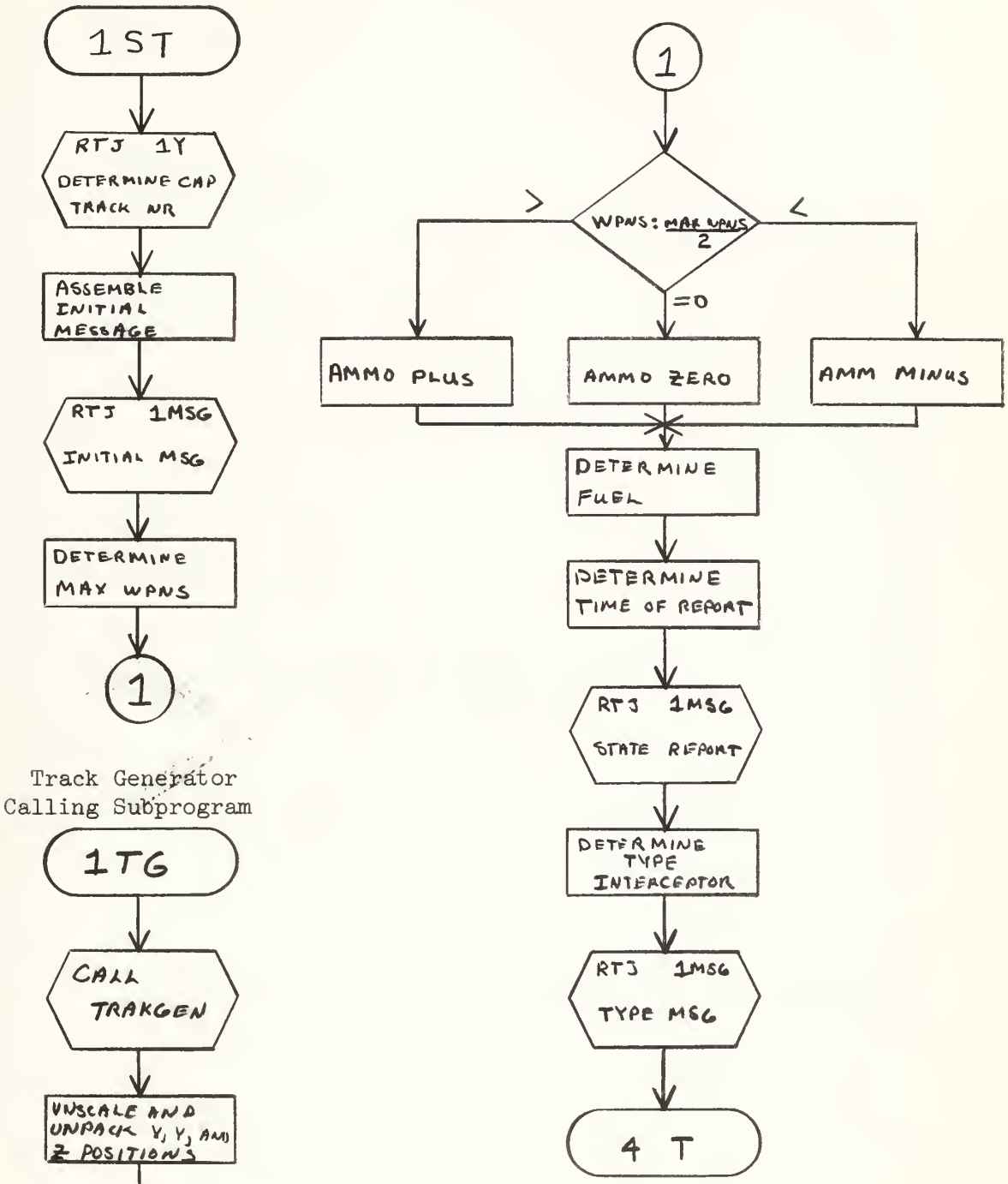


Figure I-33

State Routine



Track Generator Calling Subprogram

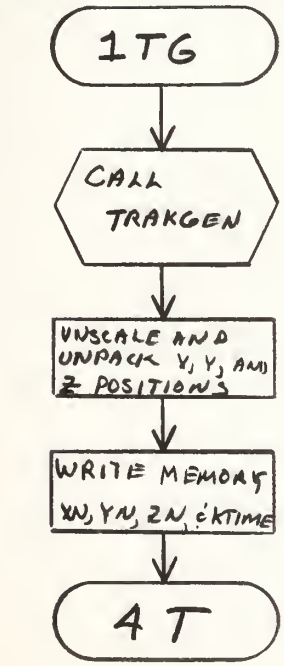


Figure I-34

Executive Routine

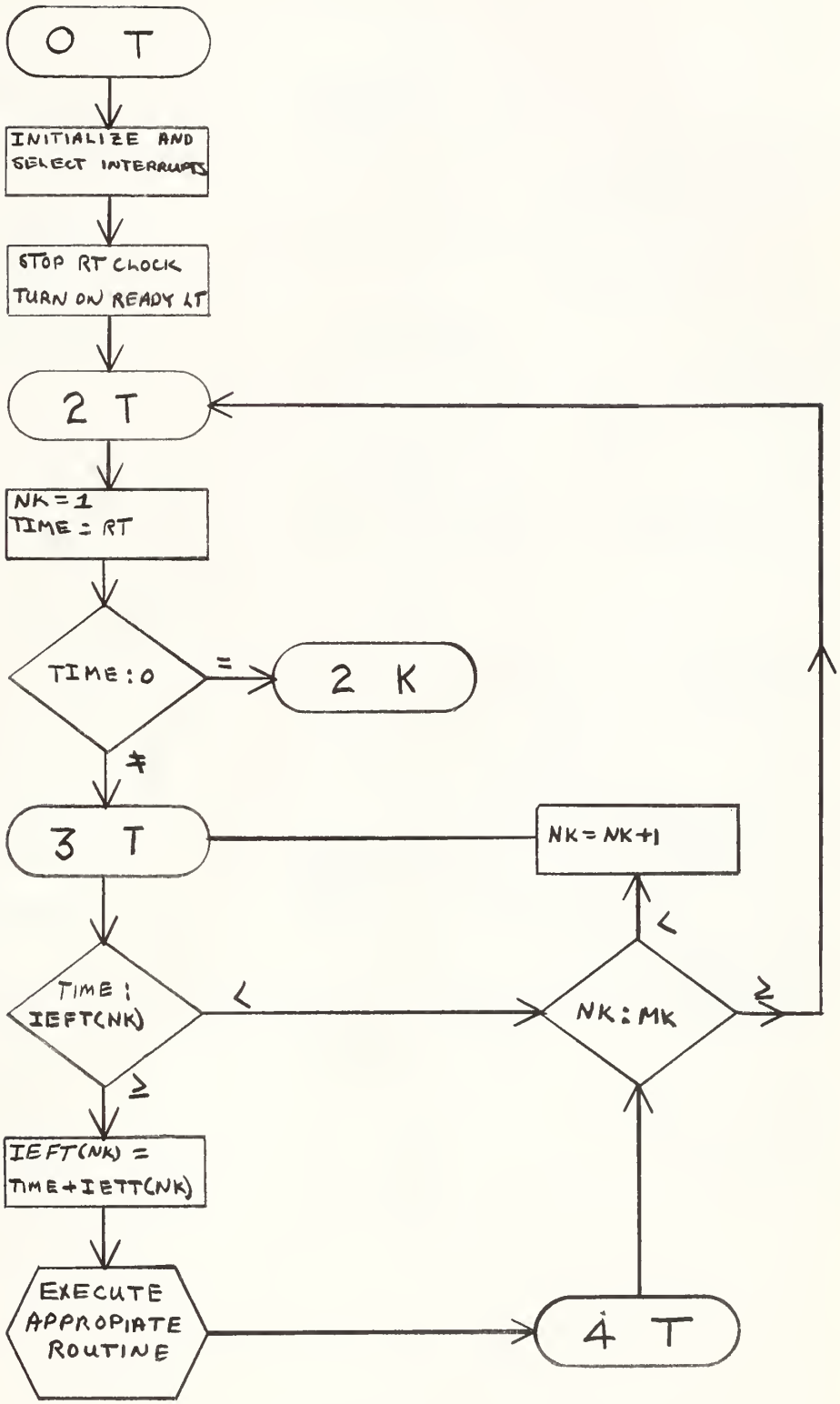


Figure I-35

INFO Routine

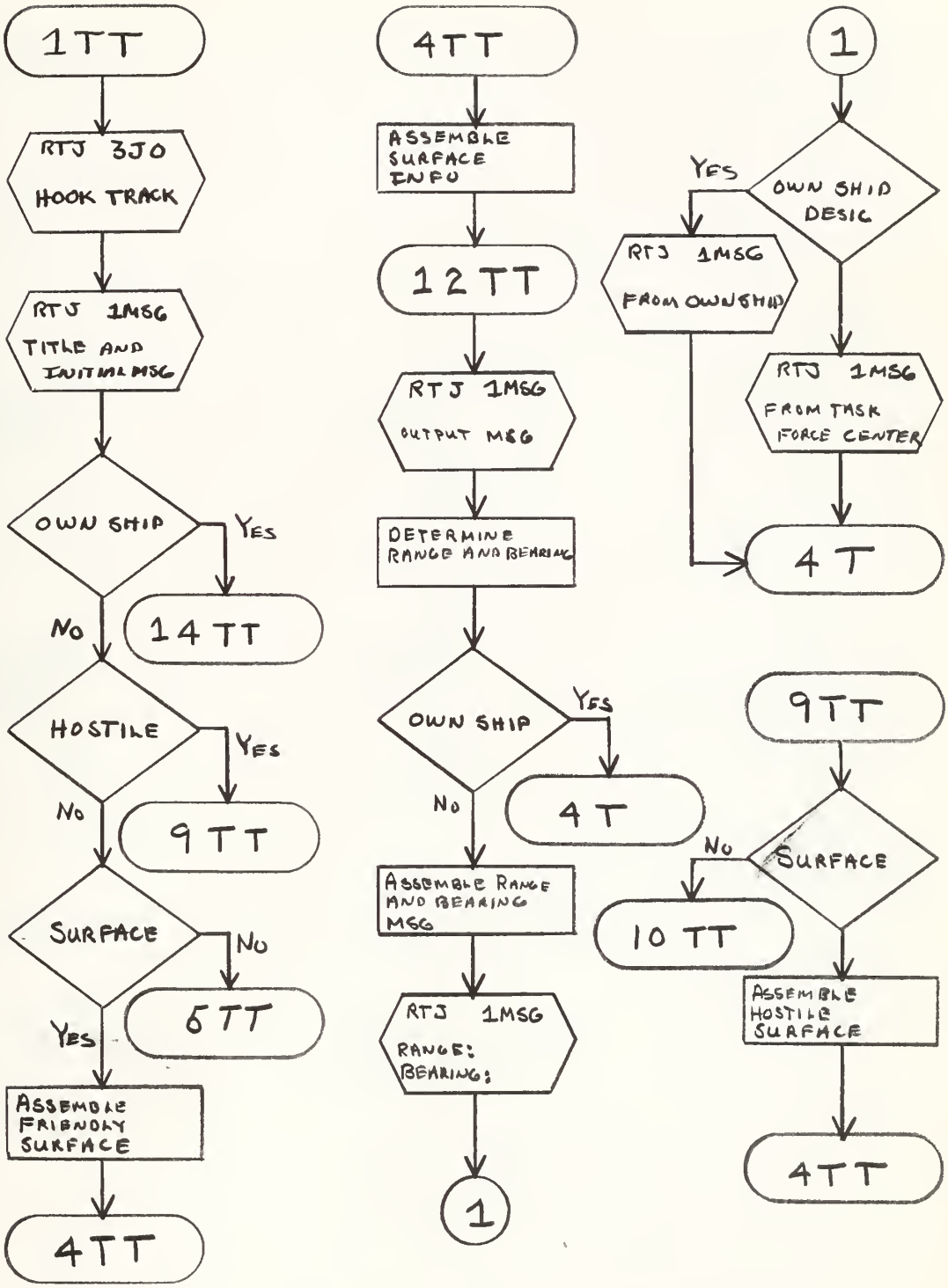


Figure I-36

INFO Routine (cont)

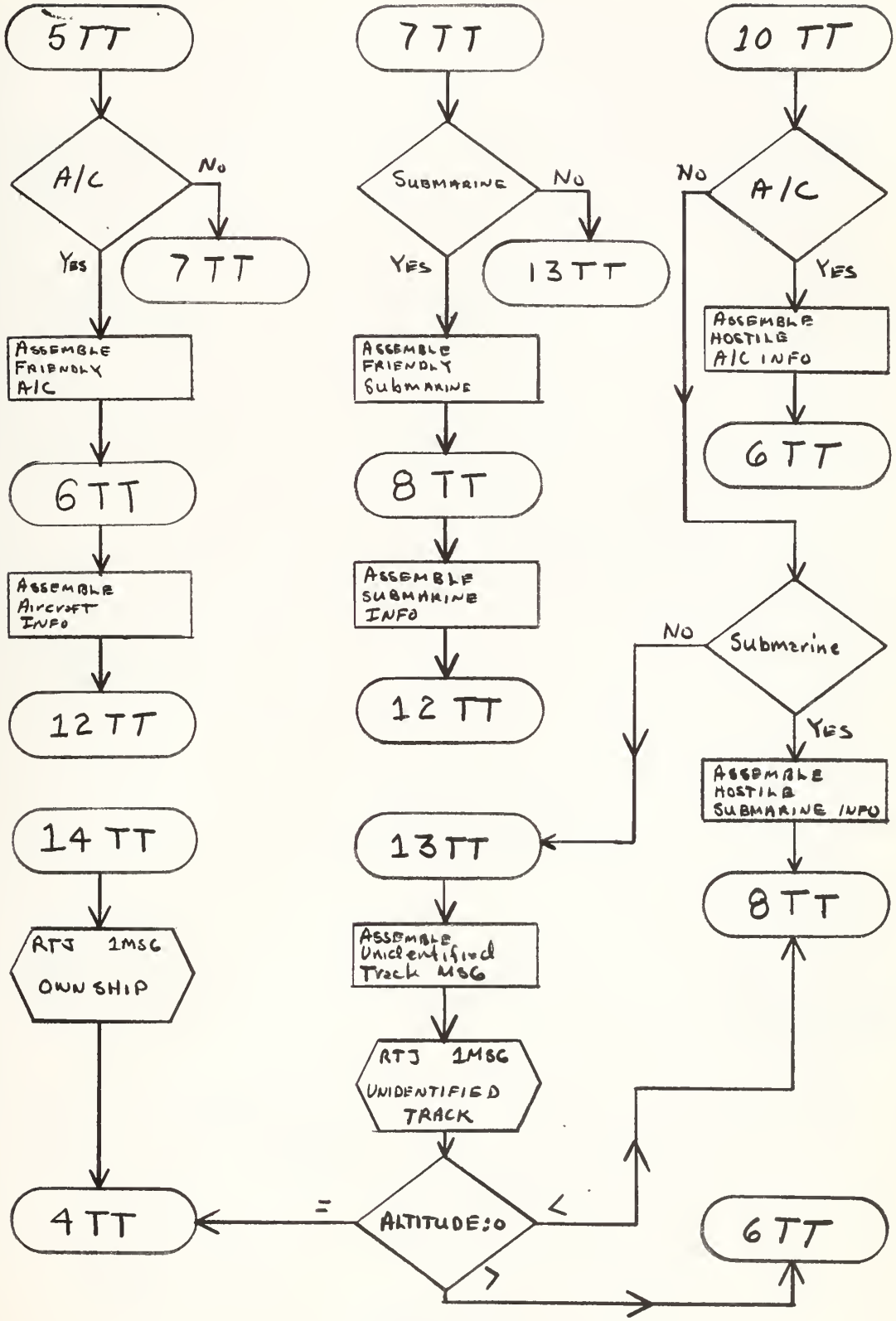


Figure I-37

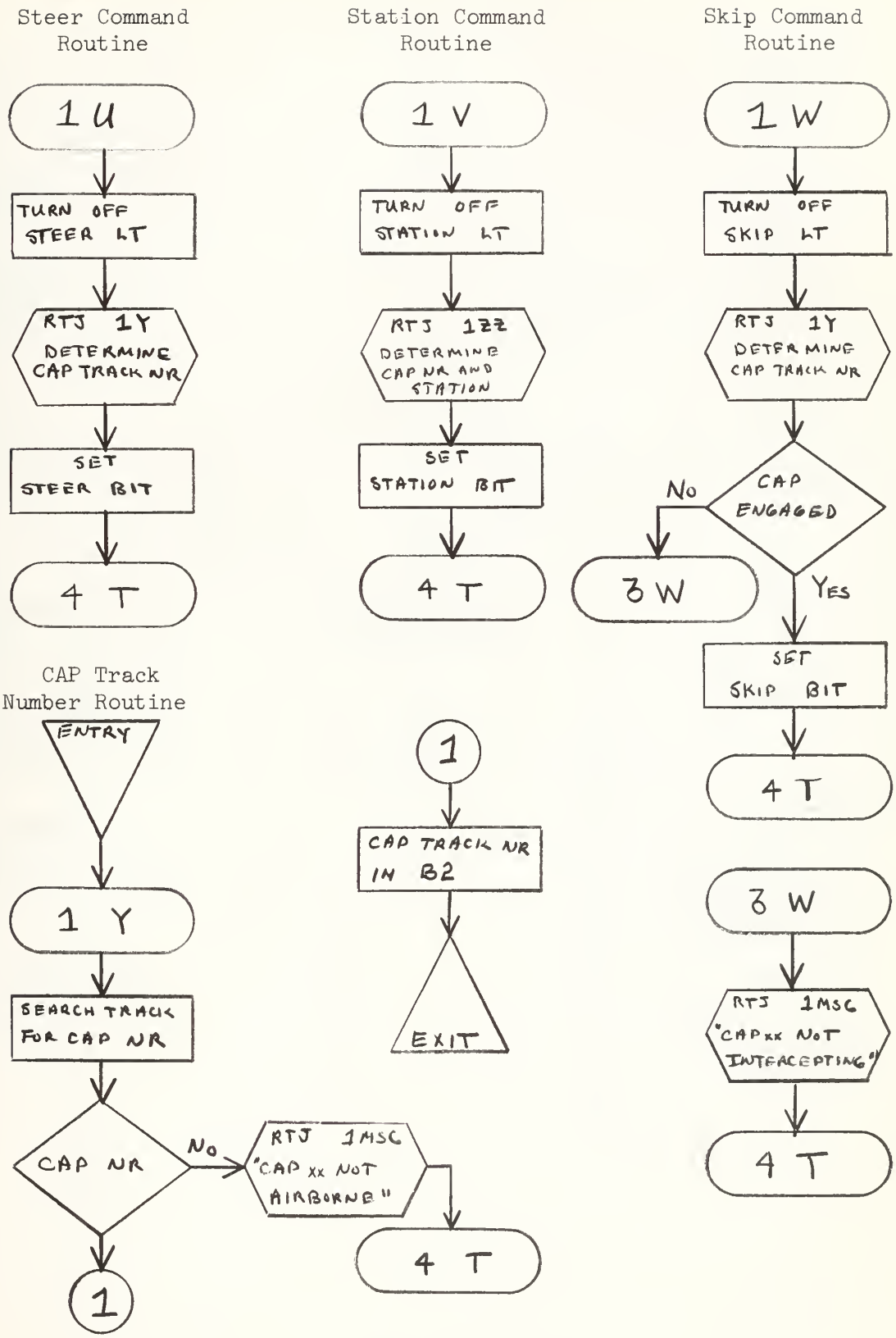

Steer Command Routine
1U
TURN OFF STEER LT
RTJ 1Y DETERMINE CAP TRACK NR
SET STEER BIT
4T
Station Command Routine
1V
TURN OFF STATION LT
RTJ 1ZZ DETERMINE CAP NR AND STATION
SET STATION BIT
4T
Skip Command Routine
1W
TURN OFF SKIP LT
RTJ 1Y DETERMINE CAP TRACK NR
CAP ENGAGED
No
3W
Yes
SET SKIP BIT
4T
CAP Track Number Routine
ENTRY
1Y
SEARCH TRACK FOR CAP NR
CAP NR
No
RTJ 1MSG "CAP xx NOT AIRBORNE"
4T
1
1
CAP TRACK NR IN B2
EXIT
3W
RTJ 1MSG "CAP xx NOT INTERCEPTING"
4T

Figure I-38

Launch Command Routine

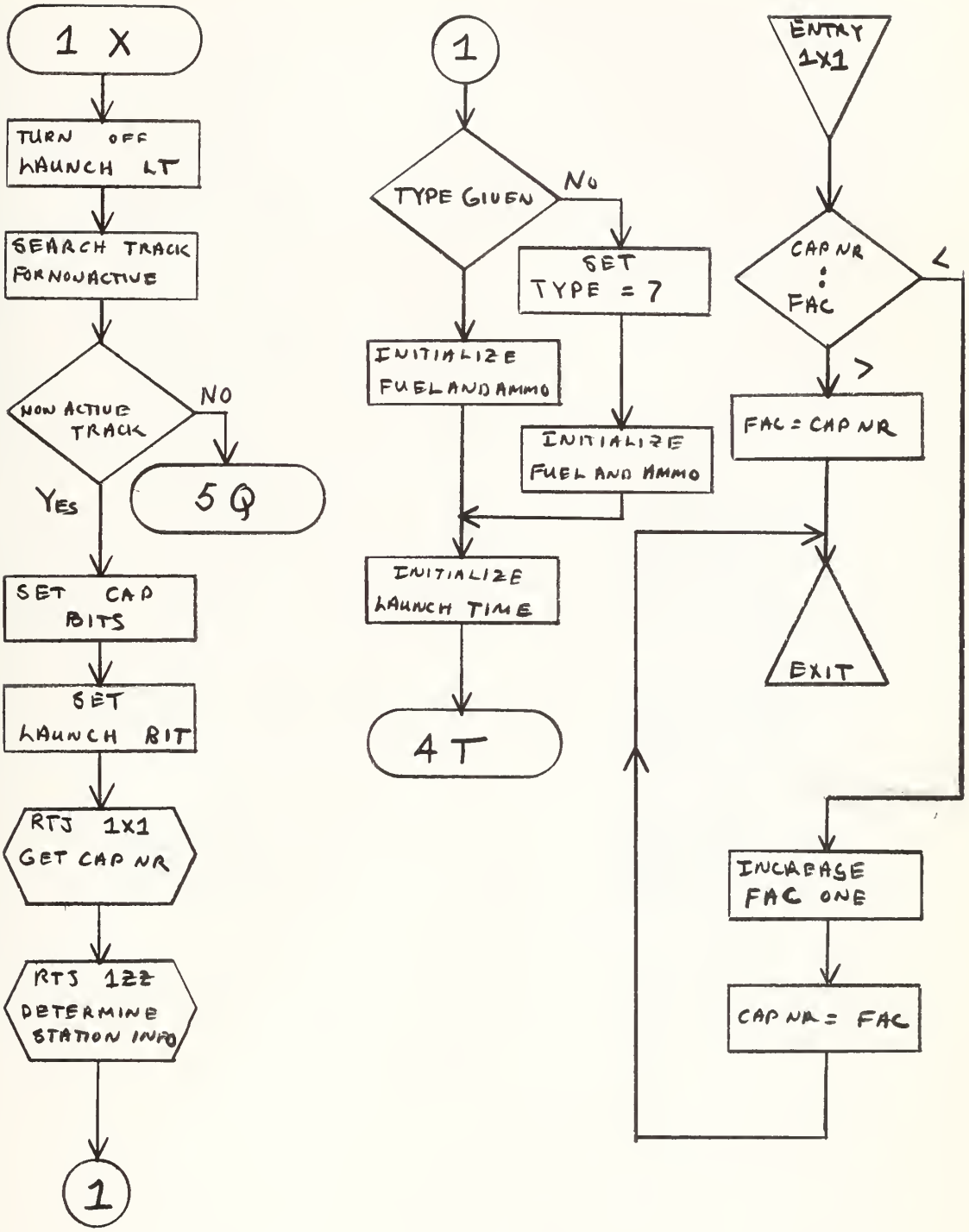


Figure I-39

Begin Routine

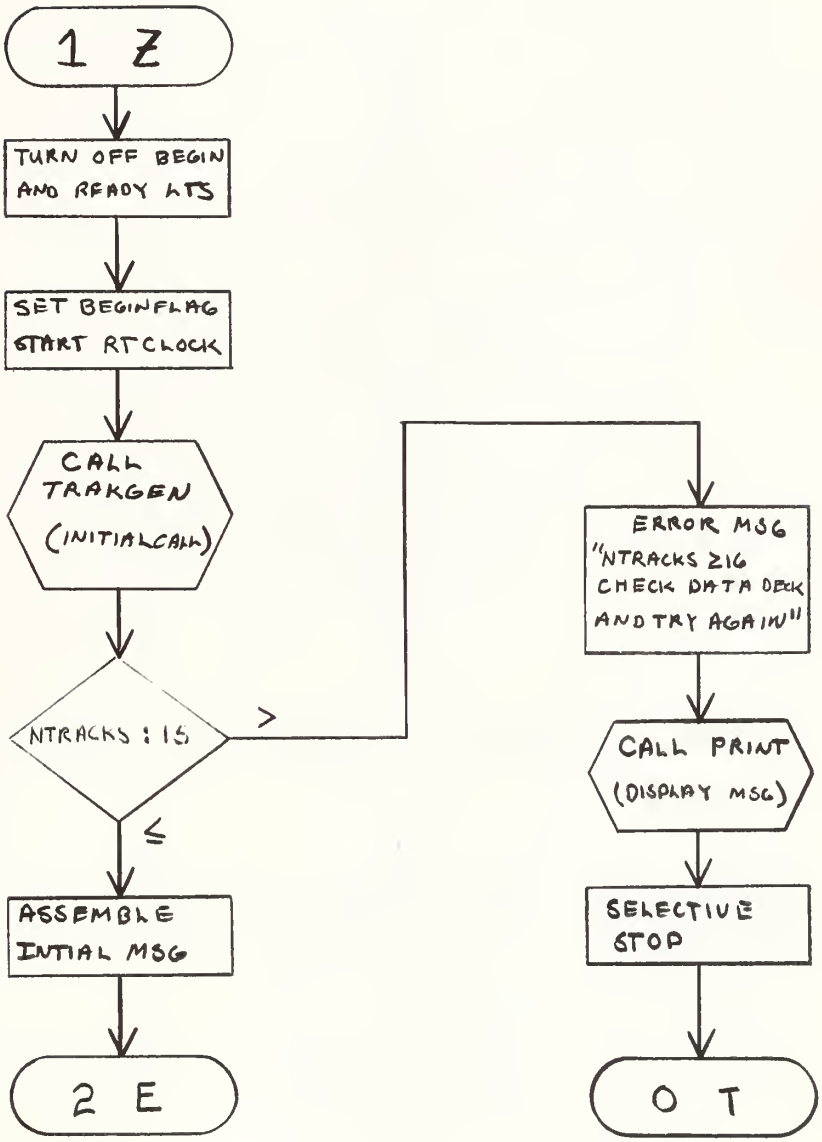


Figure I-40

CAP Track Number and Station Routine

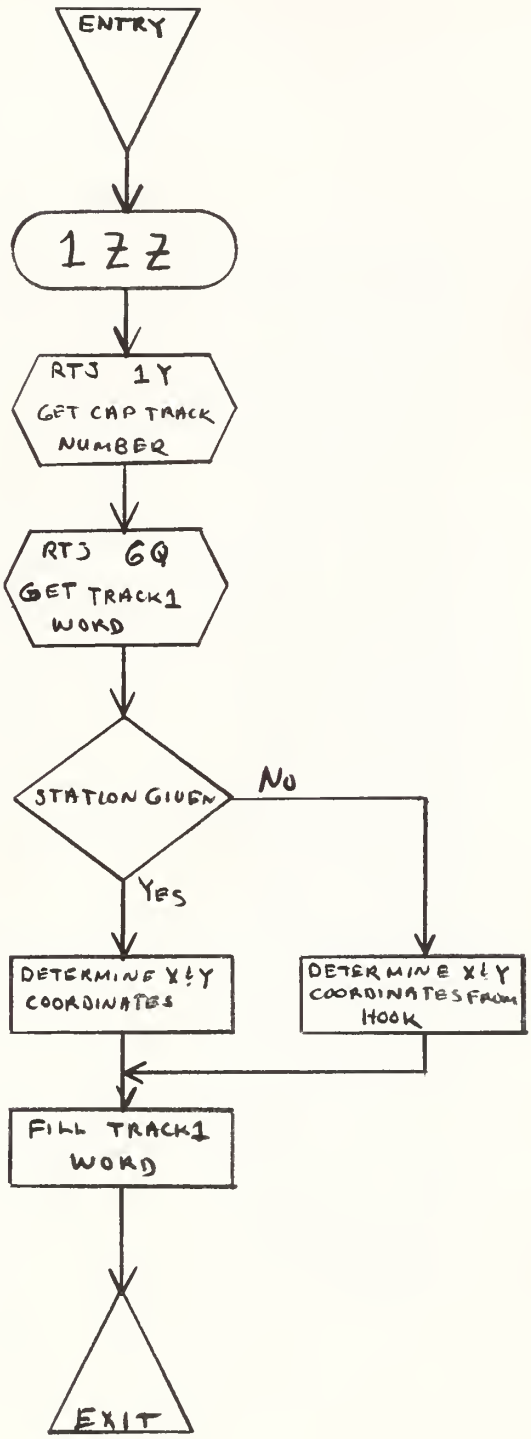


Figure I-41

```
      MACHINE SIMONE

      RSV(IPOSIT=15,IHEAD=15,JHEAD=15,IDD65=10,IEFT=6,IETT=6,BUF1=120)
      RSV(T=11,ERRMSG=4,R=4,D=15,F=15,TRACK=15,TRACK1=15,TRACK2=15)
      RSV(SPD=15,CRS=15,KTIME=4,MACH=15)
      RSV(XHIS1=24,YHIS1=24,XHIS2=24,YHIS2=24,IXH=15,IYH=15)
      RSV(XN=15,YN=15,ZN=15,XP=15,YP=15,ZP=15,XS=15,YS=15,ZS=15,
     *    VXS=15,VYS=15,VZS=15,LHEAD=60,KFIG=15)
      RSV(X=299,X1=299,X2=299,Y=299,Y1=299,Y2=299)

      LIB(TRAKGEN,PRINT,DRAW,FLOATFIX=FLOAT,FIXFLOAT=FIX,COURSE)
      LIB(SQRTF=SQ,COSF,SINF)

      COMMON IPOSIT,IHEAD,JHEAD,LHEAD,IDD65,ISCALE1,ISCALE2,SCALE1,
     *       SCALE2,TIME

      LOC(Z=0,ITIME=50)

* BCD CODE TABLE

      CON(F0 =12B,F1 =01B,F2 =02B,F3 =03B,F4 =04B,F5 =05B,F6 =06B,
     *    F7 =07B,F10=10B,F11=11B,F12=61B,F13=62B,F14=63B,F15=64B,
     *    F16=65B,F17=66B,F20=67B,F21=70B,F22=71B,F23=41B,F24=42B,
     *    F25=43B,F26=44B,F27=45B,F30=46B,F31=47B,F32=50B,F33=51B,
     *    F34=22B,F35=23B,F36=24B,F37=25B,F40=26B,F41=27B,F42=30B,
     *    F43=31B,F44=73B,F45=53B,F46=34B,F47=13B,F50=54B,F51=21B,
     *    F52=60B,F53=40B,F54=74B,F55=33B,F56=20B,F57=14B,F60=52B)

* SPECIAL SYMBOLS FOR DD-65 DISPLAY

      CON(S1  = 07005243544556478, S1A = 5041010454540401B,
     *    S1B = 00015656770000008, S1C = 0000000000000000B,
     *    S2  = 10464554434277008, S2A = 0000000000000000B,
     *    S2B = 0000000000000000B, S2C =          00000008,
     *    S3  = 07005243544556478, S3A = 5041770000000008,
     *    S3B = 0000000000000000B, S3C =          00000008,
```

```
*     S4   = 10424354454677008, S4A  = 0000000000000008,
*     S4B  = 0000000000000008, S4C  =          0000008,
*     S5   = 1012141416565050B, S5A  = 5277000000000008,
*     S5B  = 0000000000000008, S5C  =          0000008)
      CON(S6   = 1052545456565050B, S6A  = 5277000000000008,
*     S6B  = 0000000000000008, S6C  =          0000008,
*     S7   = 1052545456770008, S7A  = 0000000000000008,
*     S7B  = 0000000000000008, S7C  =          0000008,
*     S8   = 1053557700000008, S8A  = 0000000000000008,
*     S8B  = 0000000000000008, S8C  =          0000008,
*     S9   = 1013155751770008, S9A  = 0000000000000008,
*     S9B  = 0000000000000008, S9C  =          0000008,
*     S10  = 1053555751770008, S10A= 0000000000000008,
*     S10B= 0000000000000008, S10C=          0000008)
      CON(S11  = 5016155252525215B, S11A= 1657770000000008,
*     S11B= 0000777777777778, S11C= 7300000000000008,
*     S12 = 5053555077000008, S13  = 5052545456507700B)

* RAW DATA DISPLAY SYMBOLS

      CON(C360 = 4310164377000008, C090 = 4116144177000008,
*     C180 = 4310164377000008, C270 = 4116147700000008)

* MASK FOR LOADING AND UNPACKING

      CON(MASK4B = 0070000000000008, MASK8U = 0030000000000008,
*     MASK9  = 0000000777777778, MASK9L = 5000000020000308)
      CON(MASK10 = 7777777777777008, MASK11 = 0000000000000778,
*     MASK12 = 0000000000000708, MASK13 = 7400000000000008,
*     MASK14 = 4000000000000008, MASKX  = 7777777000000008,
*     MASKY  = 0000000777777778, MASK15 = 7777777777777778,
*     MASK16 = 1000000000000008, MASK17 = 2000000000000008,
*     MASK18 = 0400000000000008, MASK19 = 0000000040000008,
*     MASK20 = 0000000020000008, MASK21 = 0000000010000008,
*     MASK22 = 0000000004000008, MASK23 = 0000000002000008,
*     MASK24 = 0000000001000008, MASK25 = 0000000004000008,
```

```
*     MASK26 = 0000000002000000B, MASK27 = 0000000001000000B)
      CON(MASK30 = 0070000000000000B, MASK31 = 0000000770000000B,
*     MASK32 = 0000007700000000B, MASK33 = 0000000050600000B,
*     MASK34 = 0000000007700000B, MASK35 = 0000077000000000B)
      CON(MASK36 = 7700000000000000B, MASK37 = 0000007777777777B,
*     MASK38 = 7777777700777777B, MASK39 = 0000007700777777B)
      CON(MASK40 = 0100000000000000B)

* PROGAM NAMES

      CON(P0  = 6265677145000000B, P1  = 71452363472300000B,
*     P2  = 4361244563700000B, P3  = 70712223465130000B,
*     P4  = 6551514651000000B, P5  = 70464364000000000B,
*     P6  = 2242714700000000B, P7  = 64712247436130000B,
*     P8  = 6451464700000000B, P9  = 4546232024226564B,
*     P10 = 2223464700000000B, P11 = 2223656551000000B,
*     P12 = 6465227167000000B, P13 = 71456646000000000B,
*     P14 = 4546232024226564B, P15 = 67516147700000000B,
*     P16 = 2223612371464500B, P17 = 63706145676500000B,
*     P18 = 2223612365000000B, P19 = 4546232024226564B)
      CON(P20 = 5165616430204323B, P21 = 66616465000000000B,
*     P22 = 2445666164650000B, P23 = 2223615123000000B,
*     P24 = 2263512462000000B, P25 = 47465123000000000B,
*     P26 = 2223626400000000B, P27 = 22476565640000000B,
*     P28 = 6143237123246465B, P29 = 4546232024226564B)

* BCD MESSAGE CODE TABLE

      CON(E0 =4751466751614420B,   E1 =45462320636143430B,
*     E2 =65640000000000000B,   E3 =23464620446145300B,
*     E4 =2061516724446545B,    E5 =23220000000000000B,
*     E6 =0245642061516724B,    E7 =44654523207143430B,
*     E8 =6567614373000000B,    E9 =00002023516163420B,
*     E10=2220244564655120B,    E11=30462451206346450B,
*     E12=2351464373000000B,    E13=23615167652320450B,
*     E14=4623207046464265B,    E15=64000000000000000B)
```

```
 CON(E16=00000000000000B,   E17=24456162436520238,
*    E18=4620714523655163B,  E19=65472320402066248,
*    E20=6543000000000008,   E21=0          00000B,
*    E22=24456162436540238,  E23=4620714523655163B,
*    E24=65472320402061448,  E25=4446000000000008,
*    E26=00000000000000008,  E27=43462620222361238,
*    E28=65000000000000008,  E29=00         0000B,
*    E30=4461306461307373B,  E31=73446130646130738,
*    E32=73730000000000008,  E33=00         00000B,
*    E34=66614471227065648,  E35=00000000000000008)
 CON(E36=00000000000000008,  E37=71452265516365478,
*    E38=23714567204020248,  E39=45616243652023468,
*    E40=20516523245145008,  E41=00000000000000008,
*    E42=47464651207145238,  E43=65516365472300008,
*    E44=22474361227020208,  E45=20624667653020658,
*    E46=00000000000000008,  E47=70656164222024478,
*    E48=20624667653020658,  E49=00000000000000008)
 CON(E50=45235161634222208,  E51=37200106202020208,
*    E52=63706563422064618,  E53=23612064656342208,
*    E54=61456420235130208,  E55=61676171457300008)
 CON(E56=45462063614720618,  E57=25617143616243658,
*    E58=20234620626520438,  E59=61244563706564008,
*    E60=00000000000000008,  E61=20204546232061718,
*    E62=51624651456500008,  E63=00000000000000008,
*    E64=20204546232044618,  E65=42714567206145208,
*    E66=71452365516365478,  E67=23730000000000008)
 CON(E68=67516147702062658,  E69=71456720474346238,
*    E70=23656473000000008,  E71=67516147702066718,
*    E72=45712270730000008,  E73=20202020714566468,
*    E74=51446123714645008,  E75=20202020202020208,
*    E76=23516163422045518,  E77=00000000000000008,
*    E78=20202020202020208,  E79=00000000000000008,
*    E80=00000000000000008,  E81=0          00000B,
*    E82=00000000000000008,  E83=0*         00000B)
 CON(E84=22236123652051658,  E85=47465123204645208,
*    E86=00000000000000008,  E87=20202061444446208,
```

```
*     E88=0000000000000000B,
*     E89=4627306765452047B,    E90=43242220212066248,
*     E91=0000000000000000B,    E92=2047462445642220B,
*     E93=2120237144652020B,    E94=0000000000000000B)
      CON(E95=4626452022707147B,    E96=51614567651520208,
*     E97=2030615164220000B,    E98=6265615171456715B,
*     E99=20646567516565228,   E100=6651464420462645B,
*    E101=20227071470000008,   E102=6651464420236122B,
*    E103=4266465163652063B,   E104=65452365510000008,
*    E105=20447143652200008)

* GRAPH TITLES

      CON(ITITLE = 0)
      CON(TITLE1  = 22714420464565208, TITLE2  = 20202020206143238,
*     TITLE3  = 71232464652025228, TITLE4  = 73202371446520208,
*     TITLE5  = 20202020202020208, TITLE6  = 20202020202020208,
*     TITLE7  = 0000000000000000B, TITLE8  = 20237144652020208,
*     TITLE9  = 0000000000000000B, TITLE10 = 0000000000000000B,
*     TITLE11 = 45242365222020208, TITLE12 = 20202020202020208)
      CON(KTITLE = 0)
      CON(TITLE13 = 22714420464565208, TITLE14 = 20202020202740308,
*     TITLE15 = 20474622712371468, TITLE16 = 45204743462320208,
*     TITLE17 = 20202020202020208, TITLE18 = 20202020202020208,
*     TITLE19 = 0000000000000000B, TITLE20 = 20237144652020208,
*     TITLE21 = 0000000000000000B, TITLE22 = 0000000000000000B,
*     TITLE23 = 45242365222020208, TITLE24 = 20202020202020208)

* PTABLE

      CON(PTABLE = 0, P1 = 48, P2 = 24, P3 = 12, P4 = 8, P5 = 6, P6 = 4,
*     P7 = 3, P8 = 2, P9 = 1)

* TIMING CONSTANTS FOR DISPLAY AND READBACK

      CON(PP0 = 0000000000000000B, PP1 = 4000000000000000B,
```

```
*     PP2 = 40000000400000008, PP3 = 40004000400040008,
*     PP4 = 40100200401002008, PP5 = 40404040404040408,
*     PP6 = 42104210421042108, PP7 = 44444444444444448,
*     PP8 = 52525252525252528, PP9 = 77777777777777778)

* AIRCRAFT CONTROL CONSTANTS

      CON(LHEAD1 = 40200000000000008, LHEAD2 = 40400000000000368,
*     LHEAD3 = 40600000000240008, LHEAD4 = 41000000000000128,
*     LHEAD5 = 40400000030000178, LHEAD6 = 47200000000000368,
*     LHEAD7 = 40600001200240008, LHEAD8 = 42000000000000008,
*     LHEAD9 = 41000001700000128)

* INITITAL INTERCEPTOR INFORMATION

      CON(IFIG0 = 00000000000000008, IFIG1 = 00000000000000008,
*     IFIG2 = 20640023174043018, IFIG3 = 20640043174043018,
*     IFIG4 = 32604404376443008, IFIG5 = 32604444376443008,
*     IFIG6 = 35064404376443008, IFIG7 = 35064444376443008)

* SECOND WORD INTERCEPTOR INFORMATION

      CON(FIG  = 0.00, FIG1 = 0.00, FIG2 = 0.67, FIG3 = 0.67,
*     FIG4 = 1.18, FIG5 = 1.15, FIG6 = 1.15, FIG7 = 1.30)

* MANEUVER CODE TABLE

      CON(MAN1 = 05B, MAN2 = 06B, MAN3 = 01B, MAN4 = 10B, MAN5 = -2B,
*     MAN6 = 02B, MAN7 = 04B, MAN8 = 03B)

* BUTTON TABLE

      CON(T0  = 01B, T1  = 02B, T2  = 03B, T3  = 04B, T4  = 05B,
*     T5  = 11B, T6  = 12B, T7  = 13B, T8  = 14B, T9  = 15B,
*     T10 = 21B, T11 = 22B, T12 = 23B, T13 = 24B, T14 = 25B,
*     T15 = 31B, T16 = 32B, T17 = 33B, T18 = 34B, T19 = 35B,
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*     T20 = 41B, T21 = 42B, T22 = 43B, T23 = 44B, T24 = 45B,
*     T25 = 51B, T26 = 52B, T27 = 53B, T28 = 54B, T29 = 55B)

* LIGHT  TABLE

      CON(LT0  = 77202B, LT1  = 77204B, LT2  = 77210B, LT3  = 77220B,
*     LT4  = 77240B, LT5  = 77302B, LT6  = 77304B, LT7  = 77310B,
*     LT8  = 77320B, LT9  = 77340B, LT10 = 77402B, LT11 = 77404B,
*     LT12 = 77410B, LT13 = 77420B, LT14 = 77440B, LT15 = 77502B,
*     LT16 = 77504B, LT17 = 77510B, LT18 = 77520B, LT19 = 77540B,
*     LT20 = 77602B, LT21 = 77604B, LT22 = 77610B, LT23 = 77620B,
*     LT24 = 77640B, LT25 = 77702B, LT26 = 77704B, LT27 = 77710B,
*     LT28 = 77720B, LT29 = 77740B)

* TURN OFF LIGHT CONSTANTS

      CON(OFF0 = 77203B, OFF1 = 77205B, OFF2 = 77211B, OFF3 = 77221B,
*     OFF4 = 77241B, OFF5 = 77303B, OFF6 = 77305B, OFF7 = 77311B,
*     OFF8 = 77321B, OFF9 = 77341B, OFF10= 77403B, OFF11= 77405B,
*     OFF12= 77411B, OFF13= 77421B, OFF14= 77441B, OFF15= 77503B,
*     OFF16= 77505B, OFF17= 77511B, OFF18= 77521B, OFF19= 77541B,
*     OFF20= 77603B, OFF21= 77605B, OFF22= 77611B, OFF23= 77621B,
*     OFF24= 77641B, OFF25= 77703B, OFF26= 77705B, OFF27= 77711B,
*     OFF28= 77721B, OFF29= 77741B)

* OCTAL TO BCD CONVERSION FOR NUMBERS 0-15
      CON(OB0  = 4546B, OB1  = 1201B, OB2  = 1202B, OB3  = 1203B,
*     OB4  = 1204B, OB5  = 1205B, OB6  = 1206B, OB7  = 1207B,
*     OB8  = 1210B, OB9  = 1211B, OB10 = 0112B, OB11 = 0101B,
*     OB12 = 0102B, OB13 = 0103B, OB14 = 0104B, OB15 = 0105B)

* ASSORTED CONSTANTS

      CON(R0 = 01, R1 = 10, R2 = 100, R2A = 1000, R2B = 10000,
*     R2C= 100000, R2D= 1000000, R3 = 0000007300204020B,
```

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      *     R4 = 00000073002044718, R5 = 43412700000000008,
      *     R6 = 77777777777775718, R7 = 43310200000000138,
      *     R8 = 00022744000000008, R9 = 00332061432320208,
      *     R10= 00000000530000008, R11= 62466765302026518,
      *     R12= 66517165456443308, R13= 20222245200706008,
      *     R14= 00232064654723708, R15= 00730000000000008,
      *     R16= 02220425220000008, R17= 67466242714520008,
      *     R18= 20644367452010008, R19= 45464540646527118)
       CON(R20= 67456123656473008, R21= 44714524222021208,
      *     R22= 31655146202021208, R23= 47432422202021208,
      *     R24= 45230000000000008, R25= 0000  00115300008)
       CON(R26= 03102745000000008, R27= 20201200120000008)
       CON(RH0 = 0., RH1 = 64., RH2 = 32., RH3 = 16., RH4 = 8., RH5 = 4.,
      *     RH6 = 2., RH7 = 1.)
       CON(PIP = 30003500000050008, CLK = 37777777777770418)
       CON(CLK5 = 3777777777777428)
       CON(ERASE  = 00000000000410008, ERASE1 = 00000000171010008)
       CON(ERASE2 = 00000000144050008)
       CON(XIP = -3778, YIP = -3778)
       CON(ALPHA=.085,BETA=.009)
       CON(AXIS = 450., RADIANS = 0.01745)
       CON(ZERO = 0.0, EIGHT =8.0)
       CON(BUTTONS = 30)
       CON(ZTIME= 1800)

1RET   SLJ    (N)          SLJ    (0T)       . EXIT/ENTRY                    00000

* FORMATS USED IN PROGRAM

1      FORMAT(4A8)                                                           00001
100    FORMAT(6A8)                                                           00002
101    FORMAT(A4,1X,E6.0,1X,E6.0,1X,I2,1X,I1,1X,I1,1X,I1,1X,I1,1X,I2,1X,     00003
      *       I1,1X)
102    FORMAT(A8)                                                            00004
103    FORMAT(F10.0)                                                         00005
104    FORMAT(I2,2X,I6)                                                      00006
```

```
200   FORMAT(17H1   DUTY CYCLE =  F7.5, 16H FOR THIS RUN.    )                  00007

* INTERRUPT ROUTINE

1A    EXF 7 (00131B)    SLJ   (0A)      . TIME ADVANCE                         00010
      EXF 7 (77173B)    SLJ   (2A)      . KBD 1 INTER ROUTINE                  00011
      EXF 7 (77174B)    SLJ   (4A)      . KBD 2 INTER ROUTINE                  00012
1AA   EXF   (00070B)    EXF   (77111B)  . CLEAR BOTH ARITHEMTIC AND           00013
      SLJ   (Z+7B)      ZRO   (0)       .   DD65 INTERRUPTS                    00014

* TIME ADVANCE ROUTINE

0A    EXF   (00070B)    STA   (ASAVE)   . CLEAR FAULT                         00015
      SSK   (Z)         SLJ   (Z+7B)    . SENSE ZERO OVERFLOW                  00016
      LDA   (CLK)       STA   (Z)       . RESET ONE-SECOND COUNT               00017
      SLJ 5 (L+4)       ENI   (0)       . DOUBLE TIME ROUTINE                  00020
      RAO   (Z+50B).    EXF   (77105B)  . INCREMENT TIME AT 50                 00021
      EXF   (77103B)    LDA   (ASAVE)   . SELECT INTERRUPTS                    00022
      SLJ   (Z+7B)      ZRO   (0)       . EXIT THROUGH 7                       00023
      SLJ   (N)         LDA   (CLK5)    . RESET ONE HALF SECOUND COUNT         00024
      STA   (Z)         SLJ   (L-1)     .                                      00025

* KEYBOARD PROCESSOR   NUMBER 1
2A    SIU 4 (3A)        STA   (ASAVE)   . SAVE INDEX B4                       00026
      STQ   (QSAVE)     LIL 4 (KNR1)    . SAVE A AND Q REGISTERS               00027
      EXF   (77140B)    EXF 7 (77140B)  . B4 = KNR1   SELECT KBD1              00030
      LIL 4 (KNR1)      EXF   (77140B)  . B4 = KNR1   SELECT KBD1              00031
      INT   (BUF1)      LDA   (BUF1)    . INPUT CHARACTER                      00032
      EQS   (74B)       SLJ   (L+2)     . CHECK FOR CLOSING PAREN              00033
      SLJ   (11A)       ZRO   (0)       . YES JUMP TO PRINT ROUTINE            00034
      EQS   (73B)       SLJ   (L+2)     . CHECK FOR PERIOD                     00035
      SLJ   (11A)       ZRO   (0)       . YES JUMP TO PRINT ROUTINE            00036
      EQS   (76B)       SLJ   (L+2)     . CHECK FOR CR                         00037
      SLJ   (9A)        ZRO   (0)       .   YES JUMP TO 9A                     00040
      EQS   (36B)       SLJ   (L+2)     . CHECK FOR TAB                        00041
      SLJ   (10A)       ZRO   (0)       .   YES JUMP TO 10A                    00042
```

```
     STA 4 (BUF1)      RAO   (KNR1)     . INCREASE POINTER                  00043
3A   ENI 4 (N)         EXF   (77001B)    . RESTORE B4   DESELECT           00044
     LDA   (ASAVE)     LDQ   (QSAVE)     . RESTORE A AND Q REGISTERS         00045
     EXF   (77111B)    SLJ   (Z+7B)      . EXIT THRU CELL 7                  00046

* KEYBOARD PROCESSOR   NUMBER 2

4A   SIU 3 (6A)        SIL 4 (6A)        . SAVE INDESES                      00047
     SIU 5 (7A)        SIL 6 (7A)        .    3, 4, 5, 6                     00050
     STA   (ASAVE)     STQ   (QSAVE)     . SAVE A AND Q REGISTERS            00051
     LDA   (PFLAG)     AJP 1 (8A)        . CHECK P-FLAG                      00052
     LDQ   (MASK11)    EXF   (77120B)    . SELECT KBD2                       00053
     INT   (KBD2WD)    LDL   (KBD2WD)    . INPUT                             00054
     STA   (KBD2WD)    LIL 3 (BUTTONS)   .                                   00055
     EQS 3 (T0)        SLJ   (6A)        . WHICH BUTTON HIT                  00056
     LDA 3 (LT0)       SAU   (L+1)       .                                   00057
     EXF   (N)         LDA 3 (0TAB)      . TURN ON CORRECT LT                00060
     SAU   (5A)        ARS   (24)        .                                   00061
     STA   (T+1)       LIL 5 (T+1)       . STORE NUMBER OF LETTERS           00062
     LIL 6 (KNR1)      LDA   (KNR1)      .   IN THE NAME                     00063
     INA 5 (0)         STA   (KNR1)      . INCREAS KNR1 BY NR LETTERS        00064
5A   LDA   (N)         ENI   (0)         .                                   00065
     ENQ   (0)         LLS   (6)         . TRANSFER WORD TO BUF1              00066
     STQ 6 (BUF1)      INI 6 (1)         .                                   00067
     IJP 5 (L-2)       ENI   (0)         . LOOP                              00070
6A   ENI 3 (N)         ENI 4 (N)         . RESTORE INDEXES                   00071
7A   ENI 5 (N)         ENI 6 (N)         .   3, 4, 5, 6                     00072
     LDA   (ASAVE)     LDQ   (QSAVE)     .                                   00073
     EXF   (77001B)    EXF   (77111B)    . DESELECT AND CLEAR                00074
     SLJ   (Z+7B)      ZRO   (0)         . EXIT THRU CELL 7                  00075
8A   EXF   (77120B)    INT   (KBD2WD)    . INPUT                             00076
     LDQ   (MASK11)    LDL   (KBD2WD)    . MASK MATRIX CODE                  00077
     EQS   (F11)       SLJ   (6A)        . CHECK FOR PAUSE                   00100
     ENA   (0)         STA   (PFLAG)     . RESET P-FLAG                      00101
     SLJ   (6A)        ZRO   (0)         . RETURN                            00102
```

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* ERASE ON CARRIAGE RETURN

9A    ENA    (1)          STA    (KNR1)      . RESET POINTERS                    00103
      EXF    (77241B)     LIL 4  (BUTTONS)   . TURN OFF ERROR LT                 00104
      LDA 4  (OFF0)       SAU    (L+1)       .                                   00105
      EXF    (N)          IJP 4  (L-1)       . TURN OFF ALL LTS                  00106
      ENA    (0)          ENI 4  (120)       . ZERO OUT BUFFER                   00107
      STA 4  (BUF1)       IJP 4  (L)         .                                   00110
      EXF    (02000B)     EXF    (04001B)    . STOP RT CLOCK AND DISALLOW        00111
      ENI 4  (484)        ENI    (0)         . ERRASE DD65 MEMORY                00112
      EXF    (77010B).    OUT    (ERASE1)    .   FROM ADDRESS                    00113
      EXF    (77010B)     OUT    (S6C)       .     484 TO 510                    00114
      ISK 4  (510)        SLJ    (L-1)       . LOOP                              00115
      EXF    (04000B)     EXF    (01000B)    . ALLOW AND START RT CLOCK          00116
      SLJ    (3A)         ZRO    (0)         . RETURN                            00117

* ERASE ON TAB

10A   ENA    (353B)       STA    (YMSG)      . RESET LINE                        00120
      ENA    (400)        STA    (ADD)       . RESET MSG ADDRESS IN DD65         00121
      ENI 4  (400)        ENI    (0)         .                                   00122
      EXF    (02000B)     EXF    (04001B)    . STOP RT CLOCK AND DISALLOW        00123
      EXF    (77010B)     EXF 7  (77010B)    . ERASE DD65 MEMORY                 00124
      OUT    (ERASE2)     ENI    (0)         .   FROM ADDRESS                    00125
      EXF    (77010B)     OUT    (S6C)       .     400 TO 482                    00126
      ISK 4  (482)        SLJ    (L-1)       . LOOP                              00127
      EXF    (04000B)     EXF    (01000B)    . ALLOW AND START RT CLOCK          00130
      SLJ    (3A)         ZRO    (0)         . RETURN                            00131

* PRINT ROUTINE FOR BUFFER

11A   STA 4  (BUF1)       RAO    (KNR1)      . STORE CLOSING PAREN. OR PERIOD    00132
      SIU 2  (15A)        SIL 3  (15A)       . SAVE NEEDED INDEXES               00133
      SIU 5  (16A)        SIL 6  (16A)       .   2, 3, 4, 5, 6                   00134
      SIU 4  (L+5)        SIL 4  (13A)       .                                   00135
      ENI 3  (1)          ENI 2  (0)         . ASSEMBLE MESSAGE FOR PRINT        00136
```

```
        ENQ   (0)          STQ   (T+1)                                    00137
        LDA   (T+1)        ENI 5 (1)          .                           00140
        ALS   (6)          ADD 3 (BUF1)       .                           00141
        ISK 3 (N)          SLJ   (L+2)        . CHECK FOR END OF LETTERS  00142
        SLJ   (L+4)        ZRO   (0)          .                           00143
        ISK 5 (8)          SLJ   (L-3)        . CHECK FOR 8 CHARACTERS    00144
        STA 2 (D)          INI 2 (1)          . STORE WORD IN D ARRAY     00145
        SLJ   (L-6)        ZRO   (0)          . LOOP                      00146
        ISK 5 (8)          SLJ   (L+2)        . CHECK FOR POSITION OF LAST00147
        STA 2 (D)          SLJ   (L+2)        .   WORD                    00150
        ALS . (6)          SLJ   (L-2)        . POSITON LAST WORD         00151
        ENA   (XP1)        SAL   (PRINT+1)    . SET UP ARGUMENTS FOR PRINT00152
        ENA   (YP1)        SAL   (PRINT+2)    .                           00153
        LIL 5 (PRINT+4)    SIL 5 (T+1)        .                           00154
        LIL 5 (PRO)        SIL 5 (PRINT+3)    .                           00155
        ENI 5 (484)        SIL 5 (PRINT+4)    .                           00156
        ENA   (D)          ENI   (0)          .                           00157
        ENQ   (0B)         SLJ 4 (PRINT)      . JUMP TO PRINT             00160
        LIL 5 (T+1)        SIL 5 (PRINT+4)    . RESTORE MEMOY ADDRESS IN PRINT 00161
        ENA   (0)          STA 2 (D)          . ERASE D ARRAY             00162
13A     IJP 2 (L-1)        ENI 4 (N)          . LOOP                      00163
15A     ENI 2 (N)          ENI 3 (N)          . RESTORE INDEXES           00164
16A     ENI 5 (N)          ENI 6 (N)          .   2, 3, 4, 5, 6          00165
        SLJ   (3A)         ZRO   (0)          . RETURN THRU CELL 7        00166

* ABSOLUTE VALUE ROUTINE

1ABS    SLJ   (N)          SLJ   (L+2)        . EXIT/ENTRY                00167
2ABS    ZRO   (0)          ZRO   (0)          . ARGUMENT                  00170
        LDA 7 (2ABS)       AJP 2 (1ABS)       . A POSITIVE    RETURN      00171
        LAC 7 (2ABS)       SLJ   (1ABS)       . COMPLEMENT    RETURN      00172
        LDL   (MASK24)     AJP   (L+3)        .                           00173
        LDA 1 (TRACK)      SST   (MASK20)     . CAP HAS ASSIGNED STATION, SET 00174
        SCL   (MASK24)     STA 1 (TRACK)      .   STATION BIT, CLEAR ORBIT BIT 00175
        LDQ 2 (TRACK)      LDL   (MASK10)     . REDESIGNATE AS            00176
        STA 2 (TRACK)      ENA   (34B)        .   UNENGAGED               00177
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        RAD 2 (TRACK)      ENI    (0)        .     BOGIE                        00200
        LDQ 1 (TRACK)      LDL    (MASK10)   . REDESIGNATE AS                   00201
        STA 1 (TRACK)      ENA    (30B)      .   UNENGAGED CAP                  00202
        RAD 1 (TRACK)      LDL    (MASK20)   .                                  00203
        AJP   (L+1)        SLJ    (1IS)      . RETURN TO STATION                00204
        LDA 1 (TRACK)      SST    (MASK24)   . SET ORBIT BIT, NO                00205
        SLJ   (3IE)        ZRO    (0)        .   STATION ASSIGNED               00206

* CHANGE ROUTINE

1C      SLJ   (L+8)        ZRO    (0)        . ENTRY                            00207
2C      ZRO   (0)          ZRO    (0)        . TRACK NUMBER                     00210
3C      ZRO   (0)          ZRO    (0)        . MANEUVER CALLED                  00211
4C      ZRO   (0)          ZRO    (0)        . 3RD ARGUMENT                     00212
5C      ZRO   (0)          ZRO    (0)        . 4TH ARGUMENT                     00213
6C      ZRO   (0)          ZRO    (0)        . 5TH ARGUMENT                     00214
7C      ZRO   (0)          ZRO    (0)        . 6TH ARGUMENT                     00215
8C      ZRO   (0)          ZRO    (0)        . 7TH ARGUMENT                     00216
        LDA   (2C)         STA    (IDD65+1)  . STORE TRACK NUMBER               00217
        LDA   (3C)         ENI 4  (8)        .                                  00220
        EQS 4 (P21)        SLJ    (9C)       . SEARCH FOR MANEUVER              00221
        LDA 4 (OFF21)      SAU    (L+1)      .                                  00222
        EXF   (N)          EXF    (77511B)   . TURN OFF CHANGE AND MAN LTS      00223
        LDA 4 (MAN1)       STA    (IDD65+2)  . STORE MANCODE                    00224
        LDA 4 (0Z10)       SAU    (L+1)      . SET ENTRY ADDRESS                00225
        SLJ   (N)          ZRO    (0)        . JUMP TO PROPER ENTRY             00226
9C      ENA   (E6)         SLJ    (1E)       . ENTRY TO ERROR ROUTINE           00227
10C     LDA   (4C)         STA    (IDD65+3)  . STORE CRS                        00230
        LDA   (5C)         STA    (IDD65+4)  . STORE SPD                        00231
        LDA   (6C)         STA    (IDD65+6)  . STORE X POSIT                    00232
        LDA   (7C)         STA    (IDD65+7)  . STORE Y POSIT                    00233
        LDA   (8C)         STA    (IDD65+8)  . STORE Z POSIT                    00234
11C     ENI 4 (6)          ENA    (0)        . BEGIN EXIT ROUTINE               00235
        STA 4 (2C)         IJP 4  (L)        . ZERO ALL ARGUMENTS               00236
        ENA   (1)          STA    (IDD65+9)  . SET PERIOD FLAG                  00237
        SLJ 4 (TRAKGEN)    ZRO    (0)        . CALL TRAKGEN                     00240
```

```
        SLJ    (4T)        ZRO    (0)        . RETURN                          00241
12C     LDA    (4C)        STA    (IDD65+4)  . STORE SPD                       00242
        LDA    (5C)        AJP    (18C)      .                                 00243
        SLJ    (16C)       ZRO    (0)        .                                 00244
13C     LDA    (4C)        STA    (IDD65+3)  . STORE CRS                       00245
        LDA    (5C)        AJP    (17C)      .                                 00246
        SLJ 4  (FLOAT)     ZRO    (0)        . FLOAT RATE                      00247
        FDV    (10.)       STA    (5C)       .                                 00250
14C     LDA    (5C)        STA    (IDD65+10). STORE RATE                       00251
        SLJ    (11C)       ZRO    (0)        .                                 00252
15C     LDA    (4C)        STA    (IDD65+5)  . STORE ALTITUDE                  00253
        LDA    (5C)        AJP    (19C)      .                                 00254
16C     LDA    (5C)        SLJ 4  (FLOAT)    . FLOAT RATE                      00255
        STA    (5C)        SLJ    (14C)      .                                 00256
17C     LDA    (1.5)       STA    (5C)       . SET STD RATE TURN               00257
        SLJ    (14C)       ZRO    (0)        .                                 00260
18C     LDA    (10.)       STA    (5C)       . SET STD SPEED RATE              00261
        SLJ    (14C)       ZRO    (0)        .                                 00262
19C     LDA    (5000.)     STA    (5C)       . SET STD CLIMB/DIVE RATE         00263
        SLJ    (14C)       ZRO    (0)        . STORE RATE                      00264

* DATA DISPLAY ROUTINE

1D      EXF    (77311B)    LAC    (DFLAG)    . TURN OFF DISPALY LT             00265
        STA    (DFLAG)     SLJ    (4T)       . COMPLEMENT D-FLAG               00266

* ERROR MESSAGE ROUTINE

1E      SAL    (2E)        SAU    (6E)       .                                 00267
        EXF    (77240B)    ENI 5  (1)        . TURN ON ERROR LT                00270
2E      ENI 4  (7)         LDQ    (N)        . SET LETTER COUNT                00271
        ENA    (0)         ENI    (0)        . ZERO ACCUMLATOR                 00272
3E      LLS    (6)         QJP    (5E)       . ASSEMBLE ERROR MSG              00273
        IJP 4  (L-1)      ENI    (0)         . END WORD CHECK                  00274
        ISK 5  (4)         SLJ    (2E)       . CHECK WORD COUNT                00275
        SLJ    (5E1)       ZRO    (0)        .                                 00276
```

```
4E     LDA    (T+9)        INI 4 (-1)       .                                  00277
       ALS    (6)          ADD   (20B)      . FILL OUT WORD WITH BLANKS        00300
       IJP 4  (L-1)        STA 5 (ERRMSG)   . STORE WHEN FILLED                00301
       ISK 5  (4)          SLJ   (4E1)      . 4-WORDS   NO JUMP TO 4E1         00302
       SLJ    (5E1)        ZRO   (0)        . YES - JUMP TO 5E1                00303
4E1    ENA    (0)          ENI 4 (8)        . SET INDEX + 1                    00304
       STA    (T+9)        SLJ   (4E)       .                                  00305
5E     STA    (T+9)        ENI   (0)        . STORE MESSAGE                    00306
       SIL 4  (T+10)       LDA   (T+10)     . NATURAL END OF WORD              00307
       AJP 1  (4E)         LDA   (T+9)      .   NO JUMP TO FILL OUT ROUTINE    00310
       STA 5  (ERRMSG)     RAO   (2E)       .                                  00311
       ISK 5  (4)          SLJ   (2E)       . 4-WORDS  NO JUMP TO 2E           00312
5E1    ENA    (1)          STA   (KNR1)     . SET POINTER TO 1                 00313
       PRINT 1, ERRMSG                                                         00314
6E     ENA    (N)          STA   (T+8)      . DISPLAY MSG USING                00315
       ENA    (XP1)        SAL   (PRINT+1)  .   PRINT ROUTINE                  00316
       ENA    (YP2)        SAL   (PRINT+2)  .                                  00317
       LDA    (T+8)        LIL 5 (PRINT+4)  .                                  00320
       SIL 5  (T+6)        LIL 5 (PRO)      .                                  00321
       SIL 5  (PRINT+3)    ENI 5 (502)      .                                  00322
       SIL 5  (PRINT+4)    ENQ   (0B)       .                                  00323
       SLJ 4  (PRINT)      ZRO   (0)        .                                  00324
       LIL 5  (T+6)        SIL 5 (PRINT+4)  . RESTORE ORIGINAL ADDRESS         00325
       SLJ    (4T)         ZRO   (0)        . RETURN                           00326

* EXIT PROGRAM

1END   EXF    (77202B)     EXF   (77302B)   .   X X X X                       00327
       EXF    (77402B)     EXF   (77502B)   .   X                             00330
       EXF    (77204B)     EXF   (77210B)   .   X                             00331
       EXF    (77310B)     EXF   (77410B)   .   X X X X                       00332
       EXF    (77510B)     EXF   (77520B)   .         X                       00333
       EXF    (77540B)     EXF   (77440B)   .         X                       00334
       EXF    (77340B)     EXF   (77240B)   .   X X X X                       00335
       LDA    (COUNTER)    SLJ 4 (FLOAT)    . DUTY CYCLE CARD                  00336
       ENI    (0)          STA   (COUNTER)  . DUTY CYCLE CARD                  00337
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        LDA    (TIME)        SLJ 4 (FLOAT)     . DUTY CYCLE CARD          00340
        STA    (TIME)        ENI   (0)         . DUTY CYCLE CARD          00341
        FDV    (PERIOD)      FMU   (5.)        . DUTY CYCLE CARD          00342
        STA    (TEMP)        LDA   (COUNTER)   . DUTY CYCLE CARD          00343
        FSB    (TEMP)        FMU   (797.2E-6). DUTY CYCLE CARD            00344
        FDV    (TIME)        STA   (TEMP)      . DUTY CYCLE CARD          00345
        LDA    (1.0)         FSB   (TEMP)      . DUTY CYCLE CARD          00346
        STA    (TEMP)        ENI   (0)         . DUTY CYCLE CARD          00347
        PRINT 200, TEMP                                                   00350
        SLJ    (1RET)        ZRO   (0)         . EXIT MAIN PROGRAM        00351

* DISPLAY ROUTINE

1F      SIU 4 (10F1)         SIL 5 (10F1)      . SAVE INDEXES             00352
        SIU 6 (11F)          SLJ 4 (1MER)      . ERASE                    00353
        ENA   (2)            SAL   (PRINT+4)   .                          00354
        ENA   (S6C)          SAL   (PRINT+1)   . TASK                     00355
        SAL   (PRINT+2)      ENA   (1)         .      FORCE               00356
        SAL   (PRINT+3)      ENQ   (-0B)       .            CENTER        00357
        ENA   (S11)          SLJ 4 (PRINT)     .                  SYMBOL  00360
        ENI 4 (16)           LDQ   (MASK13)    . SET SEARCH INDEX         00361
2F      LDA   (MASK14)       ENI 5 (0)         . MANCODE = 8              00362
        MEQ 4 (IHEAD)        SLJ   (L+7)       .   NO JUMP                00363
        LDA 4 (TRACK)        STA   (T+10)      .   YES  CHECK LAUNCH BIT  00364
        LDA   (MASK23)       LDQ   (MASK23)    .                          00365
        MEQ   (T+10)         SLJ   (L+2)       . LAUNCH BIT NOT SET       00366
        LDQ   (MASK13)       SLJ   (2F)        .   DESTROY TRACK WORD     00367
        LDQ   (MASK13)       ENA   (52B)       .                          00370
        SAL 4 (TRACK)        SLJ   (2F)        .                          00371
        ENI 4 (16)           LDQ   (MASK40)    . SET INDEX FOR SEARCH     00372
        LDA   (MASK40)       ENI   (0)         . SET A FOR SEARCH         00373
        MEQ 4 (IHEAD)        SLJ   (L+8)       . CHECK FOR FADE BIT       00374
        LDQ 4 (TRACK)        LDL   (77B)       . SAVE TRACK SYMBOL        00375
        EQS   (52B)          SLJ   (L+2)       . PREVIOUS SYMBOL STORED   00376
        SLJ   (L+5)          ZRO   (0)         .    YES JUMP              00377
        STA 4 (F)            LDQ   (MASK40)    .                          00400
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        LDA 4 (TRACK)     SCL   (MASK11)  . CLEAR OLD SYMBOL                00401
        ADD   (52B)       STA 4 (TRACK)   . SET SYMBOL TO NON ACTIVE        00402
        SLJ   (L-8)       ZRO   (0)       .                                 00403
        LDA   (DFLAG)     AJP 3 (L+3)     . CHECK TUBE FOR                  00404
        ENA   (0)         STA   (RAW)     .   DISPLAY OF RAW DATA           00405
        SLJ   (3F)        ZRO   (0)       .                                 00406
        ENA   (1)         STA   (RAW)     .                                 00407
3F      ENI 4 (1)         ENI   (0)       . RAW DATA DISPLAY                00410
3FF     ENQ   (77B)       LDL 4 (TRACK)   .                                 00411
        SUB   (52B)       AJP   (7F)      .                                 00412
        LDL 4 (TRACK)     ENI   (0)       .                                 00413
        STA   (T+3)       LIL 5 (T+3)     .                                 00414
        ENA 4 (XN)        STA   (XD)      . SET DISPLAY ROUTINE             00415
        ENA 4 (YN)        STA   (YD)      .   ADDRESS                       00416
        ENI   (0)         SLJ 4 (1F0)     . LOAD X AND Y                    00417
        LDA 4 (XN)        AJP 3 (4F)      . JUMP IF X NEG                   00420
        LDA 4 (YN)        AJP 3 (5F)      . JUMP IF X POS  Y NEG            00421
        ENA   (C360)      SLJ   (L+5)     . 000 - 090                       00422
4F      LDA 4 (YN)        AJP 3 (6F)      . JUMP IF X NEG  Y NEG            00423
        ENA   (C270)      SLJ   (L+3)     . 270 - 360                       00424
5F      ENA   (C090)      SLJ   (L+2)     . 090 - 180                       00425
6F      ENA   (C180)      ENI   (0)       . 180 - 270                       00426
        ENQ   (-0B)       LIL 5 (RAW)     .                                 00427
        SIL 5 (PRINT+3)   SLJ 4 (PRINT)   . DISPLAY RAW DATA                00430
        ENA 4 (XS)        STA   (XD)      . SET DISPLAY ROUTINE             00431
        ENA 4 (YS)        STA   (YD)      .   ADDRESS                       00432
        SLJ 4 (1F0)       ZRO   (0)       .                                 00433
        LIL 6 (PRINT+2)   SIL 6 (T+5)     .                                 00434
        LIL 6 (PRINT+1)   SIL 6 (T+4)     .                                 00435
        LDA   (PRO)       ENQ   (-0B)     .                                 00436
        SAL   (PRINT+3)   LIL 5 (T+3)     .                                 00437
        ENA 5 (S1)        SLJ 4 (PRINT)   . PRINT SYMBOLS                   00440
        LIL 6 (T+4)       SIL 6 (PRINT+1) .                                 00441
        LIL 6 (T+5)       SIL 6 (PRINT+2) .                                 00442
        LDA   (PRO)       SAL   (PRINT+3) .                                 00443
        ENA   (S11C)      ENQ   (0B)      .                                 00444
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        SLJ 4 (PRINT)     ZRO   (0)       . PRINT PERIODS                    00445
7F      ISK 4 (15)        SLJ   (3FF)     . LOOP                             00446
10F     LDA   (HIS1)      AJP 1 (13F)     . HIS1 TO BE PRINTED YES JUMP      00447
12F     LDA   (HIS2)      AJP 1 (15F)     . HIS2 TO BE PRINTED YES JUMP      00450
        SLJ   (10F1)      ZRO   (0)       . RETURN                           00451
13F     ENI 4 (N)         ENI   (0)       . DISPLAY HIS1                     00452
14F     ENA 4 (XHIS1)     STA   (XD)      . SET DISPLAY ROUTINE              00453
        ENA 4 (YHIS1)     STA   (YD)      .   ADDRESS                        00454
        SLJ 4 (1F0)       ZRO   (0)       .                                  00455
        LDA   (PRO)       SAL   (PRINT+3) .                                  00456
        ENA   (S11C)      ENQ   (0B)      .                                  00457
        SLJ 4 (PRINT)     ZRO   (0)       .                                  00460
14F1    IJP 4 (14F)       SLJ   (12F)     . LOOP                             00461
15F     ENI 4 (N)         ENI   (0)       . DISPLAY HIS2                     00462
16F     ENA 4 (XHIS2)     STA   (XD)      . SET DISPLAY ROUTINE              00463
        ENA 4 (YHIS2)     STA   (YD)      .   ADDRESS                        00464
        SLJ 4 (1F0)       ZRO   (0)       .                                  00465
        LDA   (PRO)       SAL   (PRINT+3) .                                  00466
        ENA   (S11C)      ENQ   (0B)      .                                  00467
        SLJ 4 (PRINT)     ZRO   (0)       .                                  00470
16F1    IJP 4 (16F)       SLJ   (10F1)    . LOOP                             00471
10F1    ENI 4 (N)         ENI 5 (N)       .                                  00472
11F     ENI 6 (N)         SLJ   (4T)      . RETURN                           00473

* LOAD X AND Y ROUTINE

1F0     SLJ   (N)         LDA 7 (XD)      . EXIT/ENTRY                       00474
        FMU   (RHO)       SLJ 4 (FIX)     . SCALE X                          00475
        STA   (XD)        ENA   (XD)      .                                  00476
        SAL   (2ABS)      SLJ 4 (1ABS)    .                                  00477
        THS   (250)       SLJ   (7F)      . CHECK X FOR MAX                  00500
        ENA   (XD)        SAL   (PRINT+1) .                                  00501
        LDA 7 (YD)        FMU   (RHO)     . SCALE Y                          00502
        SLJ 4 (FIX)       ZRO   (0)       .                                  00503
        STA   (YD)        ENA   (YD)      .                                  00504
        SAL   (2ABS)      SLJ 4 (1ABS)    .                                  00505
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        THS    (250)          SLJ    (7F)          . CHECK Y FOR MAX                          00506
        ENA    (YD)           SAL    (PRINT+2)     .                                          00507
        SLJ    (1F0)          ZRO    (0)           . RETURN                                   00510

* RADAR PROCESSER ROUTINE

1G      SIL 2  (8G)           SIU 3  (9G)          . SAVE INDEXES                             00511
        SIL 4  (9G)           SIU 5  (10G)         .   2,3,4,5                                00512
        LDA    (KTIME)        SUB    (KTIME+1)     . DETERMINE PERIOD                         00513
        STA    (IP)           SLJ 4  (FLOAT)       . FLOAT PERIOD                             00514
        STA    (PERIOD)       FDV    (3600.)       .                                          00515
        STA    (PERIOD2)      ENI 4  (1)           . SET TRACK INDEX                          00516
2G      ENQ    (77B)          LDL 4  (TRACK)       . PUT TRACK DESIGNATION IN  A              00517
        EQS    (F60)          SLJ    (3G)          .                                          00520
        SLJ    (11G)          ZRO    (0)           . NON DESIGNATED TRACK JUMP                00521
3G      ENA    (0)            STA    (J1)          . CLEAR J1                                 00522
        SIL 4  (J1)           LDA 4  (XN)          .                                          00523
        FSB 4  (XP)           FMU    (BETA)        . VXS =  VXS(N-1)                          00524
        FDV    (PERIOD2)      FAD 4  (VXS)         .          + BETA*(XN-XP)/PERIOD2          00525
        STA 4  (VXS)          LDA 4  (XN)          .                                          00526
        FSB 4  (XP)           FMU    (ALPHA)       . XS  =  XP + ALPHA*(XN-XP)                00527
        FAD 4  (XP)           STA 4  (XS)          .                                          00530
        LDA 4  (VXS)          FMU    (PERIOD2)     . XP  =  XS + PERIOD2*VXS                  00531
        FAD 4  (XS)           STA 4  (XP)          .                                          00532
        LDA 4  (YN)           FSB 4  (YP)          .                                          00533
        FMU    (BETA)         FDV    (PERIOD2)     . VYS =  VYS(N-1)                          00534
        FAD 4  (VYS)          STA 4  (VYS)         .          + BETA*(YN-YP)/PERIOD2          00535
        LDA 4  (YN)           FSB 4  (YP)          .                                          00536
        FMU    (ALPHA)        FAD 4  (YP)          . YS  =  YP + ALPHA*(YN-YP)                00537
        STA 4  (YS)           LDA 4  (VYS)         .                                          00540
        FMU    (PERIOD2)      FAD 4  (YS)          . YP  =  YS + PERIOD2*VYS                  00541
        STA 4  (YP)           ENA 4  (VXS)         .                                          00542
        SAL    (COURSE+1)     ENA 4  (VYS)         . DETERMINE                                00543
        SAL    (COURSE+2)     ENA 4  (CRS)         .   COURSE IN DEGREES TRUE                 00544
        SAL    (COURSE+3)     ENA 4  (SPD)         .     SPEED IN MACH NUMBER                 00545
        SAL    (COURSE+6)     ENA 4  (MACH)        .                                          00546
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        SAL   (COURSE+4)   ENA 4 (ZN)       .   M = SPD(KNTS)/(661-2.5*ALT)    00547
        SAL   (COURSE+5)   SLJ 4 (COURSE)   .                                  00550
        LDA 4 (ZN)         STA 4 (ZS)       . STORE Z DATA                     00551
        STA 4 (ZP)         LDA   (J1)       .                                  00552
        EQS   (HIS1)       SLJ   (5G)       . HIS1 TO BE UPDATED  NO JUMP      00553
        SSH   (PPMC1)      SLJ   (7G)       .                                  00554
4G      ENI 2 (24)         INI 2 (-1)       . UPDATE HIS1                      00555
        LDA 2 (XHIS1)      STA 2 (XHIS1+1)  .                                  00556
        LDA 2 (YHIS1)      STA 2 (YHIS1+1)  .                                  00557
        IJP 2 (L-2)        LDA 4 (XN)       .                                  00560
        STA   (YHIS1+1)    LDA 4 (YN)       .                                  00561
        STA   (YHIS1+1)    SLJ   (7G)       .                                  00562
5G      EQS   (HIS2)       SLJ   (7G)       . HIS2 TO BE UPDATED  NO JUMP      00563
        SSH   (PPMC2)      SLJ   (7G)       .                                  00564
6G      ENI 2 (24)         INI 2 (-1)       . UPDATE HIS2                      00565
        LDA 2 (XHIS2)      STA 2 (XHIS2+1)  .                                  00566
        LDA 2 (YHIS2)      STA 2 (YHIS2+1)  .                                  00567
        IJP 2 (L-2)        LDA 4 (XN)       .                                  00570
        STA   (XHIS2+1)    LDA 4 (YN)       .                                  00571
        STA   (YHIS2+1)    ENI   (0)        .                                  00572
7G      ISK 4 (15)         SLJ   (2G)       . LOOP                             00573
7G1     LDA   (KTIME)      SLJ   (L+1)      .                                  00574
        SUB   (IPP)        AJP 3 (L+9)      .                                  00575
7G11    ENA   (60)         RAD   (IPP)      . INCREMENT IPP BY 60              00576
        LIL 3 (PPI)        ENI 4 (14)       .                                  00577
        LDA 4 (XS+1)       STA 3 (X1)       . STORE   X-SMOOTHED POINT         00600
        LDA 4 (YS+1)       STA 3 (Y1)       .         Y-SMOOTHED POINT         00601
        LDA 4 (XN+1)       STA 3 (X2)       .         X-ACTUAL   POINT         00602
        LDA 4 (YN+1)       STA 3 (Y2)       .         Y-ACTUAL   POINT         00603
        INI 3 (1)          IJP 4 (L-4)      . LOOP                             00604
        SIL 3 (PPI)        ENI   (0)        .                                  00605
7G2     ENI 4 (3)          ENI   (0)        .                                  00606
        LDA 4 (KTIME)      STA 4 (KTIME+1)  .                                  00607
8G      IJP 4 (L-1)        ENI 2 (N)        . LOOP    RESTORE INDEXES          00610
9G      ENI 3 (N)          ENI 4 (N)        . RESTORE INDEXES                  00611
10G     ENI 5 (N)          SLJ   (4T)       . RETURN                           00612
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11G    LDA 4 (XN)        AJP 1 (L+2)     .                                  00613
       LDA 4 (YN)        AJP   (7G)      .                                  00614
       LDA 4 (F)         AJP   (L+4)     . CHECK FOR PREVIOUS TRACK FADE    00615
       LDQ 4 (TRACK)     QRS   (6)       . CLEAR OLD SYMBOL                 00616
       QLS   (6)         ADL   (MASK10)  . RESTORE PREVIOUS SYMBOL          00617
       STA 4 (TRACK)     SLJ   (14G)     .                                  00620
       LDA 4 (ZN)        AJP   (12G)     . JUMP ACCORDING TO ALTITUDE       00621
       AJP 3 (13G)       ENA   (-36B)    .  UNIDENTIFIED A/C                00622
       RAD 4 (TRACK)     SLJ   (14G)     .                                  00623
12G    ENA   (-42B)      SLJ   (L-1)     .  UNIDENTIFIED SURFACE            00624
13G    ENA   (-46B)      SLJ   (L-2)     .  UNIDENTIFIED SUBMARINE          00625
14G    LDA 4 (XN)        STA 4 (XS)      . SET XP AND XS = XN               00626
       STA 4 (XP)        LDA 4 (YN)      . SET YP AND YS = YN               00627
       STA 4 (YS)        STA 4 (YP)      .                                  00630
       ENA   (0)         STA 4 (F)       . RESET F TO ZERO                  00631
       SLJ   (7G)        ZRO   (0)       .                                  00632

* 10 MIN GRAPH ROUTINE

1GR    ENA   (2GR)       SAU   (3S)      . CHANGE ADDRESSES                 00633
       SAU   (8S)        EXF   (2000B)   . STOP THE REAL TIME CLOCK         00634
       SLJ   (1S)        ZRO   (0)       . JUMP TO STOP AND CRIT ROUTINE    00635
2GR    ENA   (1END)      SAU   (3S)      .                                  00636
       SAU   (8S)        EXF   (01000B)  .                                  00637
       REWIND MM                                                            00640
       WRITE TAPE MM, XN, YN, JTIME                                         00641
       ENA   (E71)       SLJ 4 (1MSG)    . SEND GRAPH FINISHED MSG          00642
       SLJ   (4T)        ZRO   (0)       . RETURN                           00643
3GR    EXF   (77503B)    SLJ   (1GR)     . TURN OFF GRAPH LT                00644

* AIRCRAFT CONTROL ROUTINE

1INT   SIU 1 (1ISV)      SIL 2 (1ISV)    . SAVE                             00645
       SIU 3 (2ISV)      SIL 4 (2ISV)    .   INDEX                          00646
       SIU 5 (3ISV)      SIL 6 (3ISV)    .     REGISTERS                    00647
       ENI 3 (1)         ENI 5 (0)       . SET ARRAY COUNTERS               00650
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11    ISK 5 (15)        SLJ   (L+2)      . CHECK FOR LOOP END                    00651
      SLJ   (2INT)      ZRO   (0)        . JUMP IF TRACK1 ARRAY FINISHED         00652
      LDA 5 (TRACK1)    AJP   (2INT)     . JUMP IF NO FRIENDLY AIRCRAFT          00653
      ENQ   (0)         STQ   (ISFLAG)   . SET FLAGS TO ZERO                     00654
      STQ   (ICFLAG)    STQ   (IPFLAG)   .                                       00655
      STQ   (IEFLAG)    LLS   (6)        .                                       00656
      STQ   (ICNR)      QLS   (36)       . UNPACK CAP TRACK NUMBER               00657
      STQ   (KCNR)      LIL 1 (ICNR)     .                                       00660
      LDQ 1 (TRACK)     LDL   (MASK32)   .                                       00661
      ARS   (24)        STA   (JCNR)     . UNPACK CAP NUMBER                     00662
      LDL   (MASK23)    AJP 1 (1IL)      . JUMP TO LAUNCH CAP                    00663
      LDL   (MASK30)    ARS   (39)       .                                       00664
      STA   (ITYPE)     LIL 4 (ITYPE)    . UNPACK A/C TYPE                       00665
      LDA 4 (FIG)       STA   (FLOW)     . UNPACK FUEL RATE                      00666
      FMU   (PERIOD)    SLJ 4 (FIX)      . COMPUTE FUEL CONSUMPTION              00667
      STA   (T+2)       LDQ 1 (KFIG)     . INCREMENT                             00670
      ENA   (0)         LLS   (15)       .   FUEL ON BOARD                       00671
      SUB   (T+2)       AJP 3 (1IE)      . JUMP IF FUEL EXHAUSTED                00672
      STA   (T+11)      LRS   (15)       .                                       00673
      STQ 1 (KFIG)      ENA 1 (XP)       . STORE NEW FUEL QUANTITY               00674
      SAL   (2ID)       ENA 1 (YP)       . COMPUTE                               00675
      SAL   (3ID)       ENA   (0)        .   RANGE                               00676
      STA   (T+2)       ENA   (T+2)      .     FROM                              00677
      SAL   (4ID)       SAL   (5ID)      .       CARRIER                         00700
      SLJ 4 (1ID)       ZRO   (0)        .         .                             00701
      STA   (DME)       ENI   (0)        .                                       00702
      LDQ 4 (IFIG0)     LDL   (MASK31)   .                                       00703
      ARS   (21)        SLJ 4 (FLOAT)    .                                       00704
      STA   (RECOVER)   LDQ 4 (IFIG0)    .                                       00705
      LDL   (77700B)    ARS   (6)        .                                       00706
      STA   (ICRUISE)   SLJ 4 (FLOAT)    .                                       00707
      FDV   (3600.)     STA   (CRUISE)   . UNPACK CRUISE SPEED                   00710
      LDQ 4 (IFIG0)     LDL   (MASK34)   .                                       00711
      ARS   (15)        STA   (LEVEL)    . UNPACK CRUISE ALTITUDE                00712
      LDL   (1B)        AJP 1 (L+3)      .                                       00713
      ENA   (1800)      STA   (INTSPD)   . MAX SPEED+IS 1800 KNOTS               00714
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        SLJ    (L+2)        ZRO    (0)        .                                  00715
        ENA    (1200)       STA    (INTSPD)   . MAX SPEED IS 1200 KNOTS          00716
        SLJ 4  (FLOAT)      ZRO    (0)        .                                  00717
        STA    (SPDINT)     ENI    (0)        .                                  00720
        LDA    (T+11)       SLJ 4  (FLOAT)    .                                  00721
        STA    (FUEL)       LDA    (DME)      . COMPUTE                          00722
        FDV    (CRUISE)     FMU    (FLOW)     .   STEER                          00723
        FAD    (RECOVER)    FSB    (FUEL)     .     STATE                        00724
        AJP 3  (2I)         LDQ 1  (TRACK2)   . JUMP IF NOT LOW STATE            00725
        LDL    (MASK19)     AJP 1  (2IE1)     . JUMP IF MESSAGE ALREADY SENT     00726
        SLJ    (2IE)        ZRO    (0)        . SEND LOW STATE MESSAGE           00727
2I      LDQ 1  (TRACK)      LDL    (MASK19)   .                                  00730
        AJP 1  (1II)        ENI    (0)        . JUMP TO INTERCEPT                00731
5I      LDL    (MASK20)     AJP 1  (1IS)      . JUMP TO STATION                  00732
        LDL    (MASK24)     AJP 1  (2IO)      . JUMP TO ORBIT                    00733
        LDL    (MASK22)     AJP 1  (1IR)      . JUMP TO STEER                    00734
3I      SLJ    (1I)         ZRO    (0)        . END OF MAIN LOOP                 00735

* EXIT FROM AIRCRAFT CONTROL ROUTINE

2INT    ENI 5  (1)          ENI 6  (1)        . REARRANGE                        00736
        LDA 6  (TRACK1)     AJP 1  (L+3)      .   TRACK1                         00737
        ISK 6  (15)         SLJ    (L-1)      .     ARRAY                        00740
        SLJ    (L+3)        ZRO    (0)        .                                  00741
        STA 5  (TRACK1)     INI 5  (1)        .       .                          00742
        ISK 6  (15)         SLJ    (L-4)      .                                  00743
        SIL 5  (KNR2)       ENI    (0)        . SET TRACK1 POINTER               00744
1ISV    ENI 1  (*)          ENI 2  (*)        . RESTORE                          00745
2ISV    ENI 3  (*)          ENI 4  (*)        .   INDEX                          00746
3ISV    ENI 5  (*)          ENI 6  (*)        .     REGISTERS                    00747
        SLJ    (4T)         ZRO    (0)        . END AIRCRAFT CONTROL ROUTINE     00750

* COMPUTE SQUARE ROOT OF (A-C) SQUARED MINUS (B-D) SQUARED

1ID     SLJ    (*)          SLJ    (L+5)      .                                  00751
2ID     ZRO    (0)          ZRO    (0)        . A                                00752
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3ID   ZRO    (0)        ZRO    (0)      . B                                  00753
4ID   ZRO    (0)        ZRO    (0)      . C                                  00754
5ID   ZRO    (0)        ZRO    (0)      . D                                  00755
      LDA 7  (2ID)      FSB 7  (4ID)    . A-C                                00756
      STA    (T+7)      FMU    (T+7)    . (A-C) SQUARED                      00757
      STA    (T+7)      LDA 7  (3ID)    .                                    00760
      FSB 7  (5ID)      STA    (T+8)    . B-D                                00761
      FMU    (T+8)      FAD    (T+7)    . (B-D) SQUARED + (A-C) SQUARED      00762
      STA    (T+7)      ENA    (T+7)    .                                    00763
      SAL    (SQ+1)     SLJ 4  (SQ)     . TAKE SQUARE ROOT                   00764
      SLJ    (1ID)      ZRO    (0)      . RESULT IN A REGISTER               00765

* COIN FLIPPER

1IF   SLJ    (*)        LDQ    (Z)      . RETURN WITH A REGISTER             00766
      LDL    (1B)       AJP 1  (L-1)    .    - , HEADS                       00767
      ENA    (-1)       SLJ    (L-2)    .    - , TAILS                       00770

* DETERMINE SHORTEST DIRECTION OF TURN TO A GIVEN COURSE

1IT   SLJ    (*)        SLJ    (L+3)    .                                    00771
2IT   ZRO    (0)        ZRO    (0)      . ORDERED COURSE                     00772
3IT   ZRO    (0)        ZRO    (0)      . PRESENT COURSE                     00773
      LDA 7  (2IT)      FSB 7  (3IT)    . THE SIGN OF A REGISTER             00774
      SLJ 4  (FIX)      ZRO    (0)      .   DETERMINES DIRECTION OF TURN     00775
      AJP    (1IT)      ENI    (0)      .                                    00776
      STA    (T+7)      ENA    (T+7)    .                                    00777
      SAL    (2ABS)     SLJ 4  (1ABS)   .   +  STARBOARD TURN                01000
      SUB    (180)      AJP 2  (L+2)    .   -  PORT TURN                     01001
      LDA    (T+7)      SLJ    (1IT)    .   0  0  COURSE                     01002
      LAC    (T+7)      SLJ    (1IT)    .                                    01003

* SEND MESSAGE TO DISPLAY UNIT

1IE   ENA    (E29)      SLJ 4  (10IE)   . MAYDAY MESSAGE                     01005
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        LDA    (KCNR)      ADD    (LHEAD8)  .                                  01006
        STA 3  (LHEAD)     ENI    (0)       . SCRUB TRACK                      01007
        ENA    (0)         STA 5  (TRACK1)  . ERASE TRACK1 WORD                01010
        STA 5  (TRACK2)    ENI    (0)       . ERASE TRACK2 WORD                01011
        ENA    (52B)       STA 1  (TRACK)   . RESET TRACK WORD                 01012
        ISK 3  (60)        SLJ    (L+2)     .                                  01013
        ENI 3  (60)        ENI    (0)       .                                  01014
        SLJ    (1I)        ZRO    (0)       .                                  01015
2IE     ENA    (E26)       SLJ 4  (10IE)    . LOW STATE MESSAGE                01016
        LDA 1  (TRACK2)    SST    (MASK19)  .                                  01017
        STA 1  (TRACK2)    ENI    (0)       .                                  01020
2IE1    LDQ 1  (TRACK)     LDL    (MASK19)  .                                  01021
        AJP 1  (1II)       LDA 1  (TRACK)   . JUMP TO INTERCEPT                01022
        SST    (MASK22)    STA 1  (TRACK)   . SET STEER BIT                    01023
        SLJ    (1IR)       ZRO    (0)       . JUMP TO STEER ROUTINE            01024
3IE     ENA    (E33)       SLJ 4  (10IE)    . FAMISHED MESSAGE                 01025
        SLJ    (1IO)       ZRO    (0)       .                                  01026
4IE     ENA    (E16)       SLJ 4  (10IE)    . UNABLE TO INTERCEPT - FUEL MSG   01027
4I      LDA 1  (TRACK)     SST    (MASK21)  . SET SKIP BIT                     01030
        STA 1  (TRACK)     SLJ    (1II)                                        01031
5IE     ENA    (E21)       SLJ 4  (10IE)    . UNABLE TO INTERCEPT - AMMO MSG   01032
        SLJ    (4I)        ZRO    (0)       .                                  01033
6IE     ENA    (E36)       SLJ 4  (10IE)    . UNABLE TO RETURN MESSAGE         01034
        LDA 1  (TRACK2)    SST    (MASK23)  .                                  01035
        STA 1  (TRACK2)    SLJ    (3II)     .                                  01036
7IE     ENA    (E41)       SLJ 4  (10IE)    . POOR INTERCEPT MESSAGE           01037
        SLJ    (1I)        ZRO    (0)       .                                  01040
8IE     ENA    (E44)       SAL    (12IE)    . SPLASH MESSAGE                   01041
        ENA    (E46)       SLJ 4  (11IE)    .                                  01042
        SLJ    (4I)        ZRO    (0)       .                                  01043
9IE     ENA    (E47)       SAL    (12IE)    . HEADS UP MESSAGE                 01044
        ENA    (49)        SLJ 4  (11IE)    .                                  01045
        SLJ    (5IE)       ZRO    (0)       .                                  01046
10IE    SLJ    (*)         STA    (T+11)    .                                  01047
        LDA    (JCNR)      SLJ 4  (1NUM)    .                                  01050
        ALS    (6)         ADD    (R5)      .                                  01051
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        STA 7 (T+11)      LDA   (T+11)     .                                  01052
        SLJ 4 (1MSG)      ZRO   (0)        .                                  01053
        SLJ   (10IE)      ZRO   (0)        .                                  01054
11IE    SLJ   (*)         STA   (T+11)     .                                  01055
        LDA   (JBNR)      SLJ 4 (1NUM)     .                                  01056
        ALS   (39)        SCL   (77B)      .                                  01057
12IE    STA 7 (T+11)      ENA   (*)        .                                  01060
        SLJ 4 (1MSG)      ZRO   (0)        .                                  01061
        SLJ   (11IE)      ZRO   (0)        .                                  01062

* SKIP INTERCEPT

1II     LDL   (MASK21)    AJP   (2II)      . JUMP TO INTERCEPT                01063
        LDA 1 (TRACK)     SCL   (MASK33)   . CLEAR INTERCEPT                  01064
        STA 1 (TRACK)     LDQ 1 (TRACK)    .   AND SKIP BIT                   01065

* INTERCEPT ROUTINE

2II     LDQ 1 (TRACK)     LDL   (MASK20)   . IF CAP HAS ASSIGNED STATION,     01066
        AJP   (L+3)       LDA 1 (TRACK)    .   SET ORBIT BIT AS A FLAG,       01067
        SST   (MASK24)    SCL   (MASK20)   .     CLEAR STATION BIT            01070
        STA 1 (TRACK)     ENI   (0)        .                                  01071
        LDQ 1 (KFIG)      LLS   (15)       .                                  01072
        ENA   (0)         LLS   (3)        .                                  01073
        STA   (SP)        ENA   (0)        . UNPACK NUMBER OF SPARROWS        01074
        LLS   (3)         STA   (SW)       . UNPACK NUMBER OF SIDEWINDERS     01075
        LDQ 5 (TRACK1)    LLS   (6)        .                                  01076
        ENA   (0)         LLS   (6)        .                                  01077
        STA   (IBNR)      LIL 2 (IBNR)     .                                  01100
        ALS   (36)        STA   (KBNR)     .                                  01101
        LDQ 2 (TRACK)     LDL   (MASK32)   .                                  01102
        ARS   (24)        STA   (JBNR)     . UNPACK BOGIE NUMBER              01103
        LDA 2 (XP)        FSB 1 (XP)       . COMPUTE                          01104
        STA   (XDIS)      LDA 2 (YP)       .   RANGE OF                       01105
        FSB 1 (YP)        STA   (YDIS)     .     BOGIE                        01106
        FMU   (YDIS)      STA   (T+2)      .       FROM                       01107
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        LDA    (XDIS)       FMU    (XDIS)     .          CAP                    01110
        FAD    (T+2)        STA    (T+2)      .            .                    01111
        ENA    (T+2)        SLJ 4  (SQ)       .              .                  01112
        STA    (BC)         ENI    (0)        .                .                01113
        ENA    (XDIS)       SAL    (COURSE+1).  COMPUTE                         01114
        ENA    (YDIS)       SAL    (COURSE+2).    BEARING                       01115
        ENA    (CAPB)       SAL    (COURSE+3).      OF                          01116
        ENA    (0)          STA    (T+2)      .        BOGIE                    01117
        ENA    (T+2)        SAL    (COURSE+4).          FROM                    01120
        SAL    (COURSE+5)   SLJ 4  (COURSE)   .            CAP                  01121
        SLJ    (7I)         ZRO    (0)        .                                 01122

* DOES CAP HAVE ENOUGH FUEL FOR INTERCEPT

3II     SLJ    (*)          ENI    (0)        .                                 01123
        LDA    (YBI)        FMU    (YBI)      . COMPUTE AMOUNT                  01124
        STA    (T+2)        LDA    (XBI)      .   OF FUEL NEEDED                01125
        FMU    (XBI)        FAD    (T+2)      .     TO TRAVEL FROM              01126
        STA    (T+2)        ENA    (T+2)      .       PRESENT POSITION          01127
        SAL    (SQ+1)       SLJ 4  (SQ)       .   TO COLLISION INTERCEPT        01130
        STA    (T+2)        ENA    (XBI)      .     POINT AND THEN              01131
        SAL    (2ID)        ENA    (YBI)      .       TO CARRIER TO             01132
        SAL    (3ID)        ENA 1  (XP)       .   ARRIVE WITH 600 POUNDS        01133
        SAL    (4ID)        ENA 1  (YP)       .     OF FUEL                     01134
        SAL    (5ID)        SLJ 4  (1ID)      .                                 01135
        STA    (T+3)        FAD    (T+2)      .                                 01136
        FDV    (CRUISE)     FMU    (FLOW)     .                                 01137
        FAD    (600.)       FSB    (FUEL)     .                                 01140
        AJP 2  (L+1)        SLJ    (3II)      . A JUMP IF SHORT OF FUEL         01141
        LDA    (T+3)        FDV    (CRUISE)   . COMPUTE AMOUNT OF FUEL          01142
        FMU    (FLOW)       FSB    (FUEL)     .   TO REACH BOGIE                01143
        AJP 2  (4IE)        LDQ 1  (TRACK2)   . JUMP IF UNABLE TO INTERCEPT     01144
        LDL    (MASK23)     AJP 1  (3II)      .                                 01145
        SLJ    (6IE)        ZRO    (0)        . JUMP IF UNABLE TO RETURN        01146
7I      LDQ 1  (TRACK)      LDL    (MASK25)   .                                 01147
        AJP 1  (1IC)        ENA    (1)        . JUMP IF COLLISION INTERCEPT     01150
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        STA   (ICFLAG)     LDL   (MASK26)  . SET INITIAL COLLISION FLAG      01151
        AJP 1 (1IP)        ENA   (1)       .                                 01152
        STA   (IPFLAG)     LDA   (SP)      . SET INITIAL PURSUIT FLAG        01153
        AJP 1 (1IC)        ENI   (0)       . JUMP IF SPARROWS ON BOARD       01154
9I      ENA   (1)          STA   (ISFLAG)  .                                 01155
        SLJ   (6I)         ZRO   (0)       . JUMP IF NO SPARROWS             01156

* COLLISION INTERCEPT

1IC     LDA   (BC)         FSB   (10.)     .                                 01157
        AJP 2 (L+5)        ENA   (1)       . JUMP IF OUTSIDE KILL RANGE      01160
        STA   (IEFLAG)     SLJ 4 (1IF)     . SET ENGAGED FLAG                01161
        AJP 2 (L+2)        RSO   (SP)      . MISS WITH SPARROW               01162
        AJP   (9I)         ENI   (0)       . JUMP IF NO SPARROWS             01163
        RSO   (SP)         SLJ   (1IK)     . HIT WITH SPARROW                01164
        LDA 2 (CRS)        FSB   (CAPB)    .                                 01165
        STA   (T+2)        ENA   (T+2)     .                                 01166
        SAL   (2ABS)       SLJ 4 (1ABS)    .                                 01167
        FMU   (.0174533)   STA   (ALFA)    .                                 01170
        ENA   (ALFA)       ENI   (0)       .                                 01171
        SAL   (COSF+1)     SLJ 4 (COSF)    .                                 01172
        FMU   (BC)         STA   (BP)      .                                 01173
        ENA   (ALFA)       SAL   (SINF+1)  .                                 01174
        SLJ 4 (SINF)       ZRO   (0)       .                                 01175
        FMU   (BC)         STA   (CP)      .                                 01176
        LDA 1 (SPD)        FDV 2 (SPD)     .                                 01177
        STA   (T+2)        FMU   (T+2)     .                                 01200
        FSB   (1.)         STA   (T+2)     .                                 01201
        LDA   (CP)         FDV   (BP)      .                                 01202
        STA   (T+3)        FMU   (T+3)     .                                 01203
        FAD   (1.)         FMU   (T+2)     .                                 01204
        FAD   (1.)         STA   (ARG)     .                                 01205
        AJP 2 (L+4)        LDA   (SPDINT)  . CHECK IF CAP ACCELERATING        01206
        FSB   (10.)        FSB 1 (SPD)     .                                 01207
        AJP 2 (L+3)        LDA 1 (TRACK)   . JUMP IF UNABLE TO INTERCEPT     01210
        SCL   (MASK25)     STA 1 (TRACK)   . CLEAR COLLISION BIT             01211
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SLJ    (6I)          ZRO    (0)          . JUMP IF UNABLE TO INTERCEPT      01212
LDA 1  (TRACK)       SST    (MASK25)     . SET COLLISION BIT                01213
STA 1  (TRACK)       SLJ    (1IP)        . TEMPORARY PURSUIT INTERCEPT      01214
LDA 1  (SPD)         FMU 1  (SPD)        .                                  01215
STA    (T+2)         LDA 2  (SPD)        .                                  01216
FMU 2  (SPD)         FAD    (T+2)        .                                  01217
STA    (T+2)         LDA 2  (SPD)        .                                  01220
FMU 2  (SPD)         FMU    (BP)         .                                  01221
FDV    (T+2)         STA    (A)          .                                  01222
ENA    (ARG)         SAL    (SQ+1)       .                                  01223
SLJ 4  (SQ)          ZRO    (0)          .                                  01224
STA    (SQARG)       LDA    (-1.)        .                                  01225
FSB    (SQARG)       STA    (B1)         .                                  01226
FMU    (A)           STA    (B3)         .                                  01227
LDA    (-1.)         FAD    (SQARG)      .                                  01230
STA    (B2)          FMU    (A)          .                                  01231
STA    (B4)          LDA    (B3)         .                                  01232
AJP    (L+9)         AJP 2  (L+9)        .                                  01233
LDA    (B4)          AJP 3  (L+2)        .                                  01234
SLJ    (L+5)         ZRO    (0)          .                                  01235
LDA    (SPDINT)      FSB    (10.)        .                                  01236
FSB 1  (SPD)         AJP 2  (L+3)        . JUMP IF UNABLE TO INTERCEPT      01237
LDA 1  (TRACK)       SCL    (MASK25)     . CLEAR COLLISION BIT              01240
STA 1  (TRACK)       SLJ    (6I)         . JUMP IF UNABLE TO INTERCEPT      01241
LDA 1  (TRACK)       SST    (MASK25)     . SET COLLISION BIT                01242
STA 1  (TRACK)       SLJ    (1IP)        . TEMPORARY PURSUIT INTERCEPT      01243
LDA    (B4)          STA    (BI)         . BI = B4                          01244
SLJ    (L+8)         ZRO    (0)          .                                  01245
LDA    (B4)          AJP    (L+4)        .                                  01246
AJP 2  (L+3)         ENI    (0)          .                                  01247
LDA    (B3)          STA    (BI)         . BI = B3                          01250
SLJ    (L+4)         ZRO    (0)          .                                  01251
LDA    (B3)          FSB    (B4)         .                                  01252
AJP    (L-3)         AJP 3  (L-3)        .                                  01253
AJP 2  (L-8)         ZRO    (0)          .                                  01254
LDA 2  (CRS)         FMU    (.0174533)   . CONVERT COURSE                   01255
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STA    (BCRS)       ENI    (0)        .   TO RADIANS
LDA    (BCRS)       FSB    (4.7124)   .
AJP 2  (L+2)        LDA    (BCRS)     .
FSB    (1.5708)     AJP 2  (L+5)      .
ENA    (BCRS)       SAL    (COSF+1)   .
SLJ 4  (COSF)       ZRO    (0)        .
FMU    (BI)         FAD 2  (XP)       .
STA    (XBI)        SLJ    (L+6)      .
ENA    (BCRS)       SAL    (COSF+1)   .
SLJ 4  (COSF)       ZRO    (0)        .
FMU    (BI)         STA    (T+2)      .
LDA 2  (XP)         FSB    (T+2)      .
STA    (XBI)        ENI    (0)        .
ENA    (BCRS)       SAL    (SINF+1)   .
SLJ 4  (SINF)       ZRO    (0)        .
FMU    (BI)         FAD 2  (YP)       .
STA    (YBI)        LDA    (ICFLAG)   .
AJP    (L+1)        SLJ 4  (3II)      . CHECK FOR ENOUGH FUEL
ENA    (XBI)        SAL    (COURSE+1). COMPUTE
ENA    (YBI)        SAL    (COURSE+2).   ORDERED
ENA    (CCRS)       SAL    (COURSE+3).     COURSE
ENA    (0)          STA    (T+2)      .       .
ENA    (T+2)        SAL    (COURSE+4).         .
SAL    (COURSE+5)   SLJ 4  (COURSE)   .           .
ENA    (CCRS)       SAL    (2IT)      . DETERMINE BEST
LDQ 1  (IHEAD)      LDL    (7777B)    .   DIRECTION TO TURN
ARS    (12)         ENQ    (0)        .
DVI    (10)         STA    (T+3)      .
ENA    (T+3)        SAL    (3IT)      .
SLJ 4  (1IT)        ZRO    (0)        .
AJP    (L+8)        AJP 3  (L+2)      . ON COURSE
LDA    (LHEAD2)     SLJ    (L+2)      . STARBOARD TURN
LDA    (LHEAD6)     ENI    (0)        . PORT TURN
STA    (T+2)        LDA    (CCRS)     .
SLJ 4  (FIX)        ZRO    (0)        .
ALS    (18)         ADD    (KCNR)     .
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        ADD    (T+2)        STA 3 (LHEAD)    . ORDER TURN                          01322
        ISK 3  (60)         SLJ   (L+2)      .                                     01323
        ENI 3  (60)         ENI   (0)        .                                     01324
        LDA 2  (ZP)         FSB   (2500.)    . SET CAP ALTITUDE                    01325
        AJP 2  (L+2)        LDA   (1750B)    .   TO BOGIE ALTITUDE                 01326
        STA    (T+2)        SLJ   (L+3)      .     LESS 2000 FEET OR               01327
        LDA 2  (ZP)         FSB   (2000.)    .       TO 1000 FEET IF               01330
        STA    (T+2)        SLJ 4 (FIX)      .         BOGIE IS BELOW              01331
        ALS    (18)         ADD   (LHEAD3)   .           2500 FEET                 01332
        ADD    (KCNR)       STA 3 (LHEAD)    .             .                       01333
        ISK 3  (60)         SLJ   (L+2)      .                                     01334
        ENI 3  (60)         ENI   (0)        .                                     01335
        LDQ 1  (IHEAD)      LDL   (7777B)    . UNPACK CAP SPEED                    01336
        STA    (T+2)        SUB   (INTSPD)   .                                     01337
        AJP    (L+5)        LDA   (LHEAD4)   . JUMP IF INTERCEPTOR AT SPEED        01340
        ADD    (KCNR)       STA   (T+3)      .                                     01341
        LDA    (T+2)        ALS   (18)       .                                     01342
        ADD    (T+3)        STA 3 (LHEAD)    . ORDER SPEED                         01343
        ISK 3  (60)         SLJ   (L+2)      .                                     01344
        ENI 3  (60)         ENI   (0)        .                                     01345
        LDA 1  (TRACK)      SST   (MASK25)   . SET COLLISION BIT                   01346
        STA 1  (TRACK)      SLJ   (2I)       .                                     01347
6I      LDA    (SW)         AJP 1 (1IP)      . JUMP IF SIDEWINDERS ON BOARD        01350
        LDA    (ISFLAG)     AJP   (1IP)      . JUMP IF AMMO NOT EXHAUSTED          01351
        LDA    (IEFLAG)     AJP 1 (9IE)      . JUMP IF CAP ENGAGED, NO AMMO        01352
        AJP    (5IE)        ENI   (0)        . JUMP IF AMMO EXHAUSTED              01353

* PURSUIT INTERCEPT

1IP     LDA    (ICFLAG)     AJP   (L+4)      . CHECK FOR ENOUGH                    01354
        LDA 2  (XP)         STA   (XBI)      .   FUEL FOR                          01355
        LDA 2  (YP)         STA   (YBI)      .     INTERCEPT                       01356
        SLJ 4  (3II)        ZRO   (0)        .                                     01357
        LDA    (BC)         FSB   (2.5)      .                                     01360
        AJP 2  (2IP)        SLJ 4 (1IF)      . JUMP IF OUTSIDE KILL RANGE          01361
        AJP 3  (L+4)        LDA   (SW)       . JUMP IF MISS                        01362
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        AJP   (L+2)       RSO   (SW)      . HIT WITH SIDEWINDER                01363
        SLJ   (1IK)       ZRO   (0)       .                                    01364
        RSO   (SP)        SLJ   (1IK)     . HIT WITH SPARROW                   01365
        LDA   (SW)        AJP   (L+3)     . JUMP IF NO SIDEWINDERS             01366
        RSO   (SW)        AJP   (L+5)     . JUMP IF NO SECOND SIDEWINDER       01367
        RSO   (SW)        SLJ   (1IK)     . HIT WITH SECOND SIDEWINDER         01370
        LDA   (ISFLAG)    AJP 1 (9IE)     . JUMP IF NO SPARROWS                01371
        RSO   (SP)        AJP   (9IE)     . MISS WITH SPARROW                  01372
        RSO   (SP)        SLJ   (1IK)     . HIT WITH SPARROW                   01373
        LDA   (ISFLAG)    AJP 1 (9IE)     . JUMP IF NO SPARROWS                01374
        RSO   (SP)        SLJ   (1IK)     . HIT WITH SPARROW                   01375
2IP     ENA   (CAPB)      SAL   (2IT)     . DETERMINE BEST                     01376
        LDQ 1 (IHEAD)     LDL   (7777B)   .   DIRECTION TO TURN                01377
        ARS   (12)        ENQ   (0)       .                                    01400
        DVI   (10)        STA   (T+3)     .                                    01401
        ENA   (T+3)       SAL   (3IT)     .                                    01402
        SLJ 4 (1IT)       ZRO   (0)       .                                    01403
        AJP   (L+8)       AJP 3 (L+2)     . ON COURSE                          01404
        LDA   (LHEAD2)    SLJ   (L+2)     . STARBOARD TURN                     01405
        LDA   (LHEAD6)    ENI   (0)       . PORT TURN                          01406
        STA   (T+2)       LDA   (CAPB)    .                                    01407
        SLJ 4 (FIX)       ZRO   (0)       .                                    01410
        ALS   (18)        ADD   (KCNR)    .                                    01411
        ADD   (T+2)       STA 3 (LHEAD)   . ORDER TURN TO COURSE               01412
        ISK 3 (60)        SLJ   (L+2)     .                                    01413
        ENI 3 (60)        ENI   (0)       .                                    01414
        LDA 2 (ZP)        SLJ 4 (FIX)     .                                    01415
        ALS   (18)        ADD   (KCNR)    .                                    01416
        ADD   (LHEAD3)    STA 3 (LHEAD)   . ORDER ALTITUDE EQUAL BOGIE ALT     01417
        ISK 3 (60)        SLJ   (L+2)     .                                    01420
        ENI 3 (60)        ENI   (0)       .                                    01421
        ENI   (0)         LDA 2 (SPD)     .                                    01422
        FMU   (1.15)      STA   (T+2)     . ORDER SPEED EQUAL                  01423
        FSB   (SPDINT)    AJP 3 (L+2)     .   TO BOGIE SPEED                   01424
        LDA   (INTSPD)    SLJ   (L+2)     .   PLUS 15 PERCENT                  01425
        LDA   (T+2)       SLJ 4 (FIX)     .                                    01426
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      ALS    (18)        ADD    (KCNR)     .                                  01427
      ADD    (LHEAD4)    STA 3  (LHEAD)    .                                  01430
      ISK 3  (60)        SLJ    (L+2)      .                                  01431
      ENI 3  (60)        ENI    (0)        .                                  01432
      LDQ 1  (TRACK)     LDL    (MASK26)   .                                  01433
      AJP 1  (1I)        LDA 1  (TRACK)    . JUMP IF MESSAGE ALREADY SENT      01434
      SST    (MASK26)    STA 1  (TRACK)    .                                  01435
      SLJ    (7IE)       ZRO    (0)        .                                  01436

* INTERCEPTOR KILL, SPLASH BOGIE

1IK   LDA    (LHEAD8)    ADD    (KBNR)     . SPLASH BOGIE                     01437
      STA 3  (LHEAD)     ENI    (0)        .                                  01440
      ENA    (0)         STA 5  (TRACK1)   .                                  01441
      STA 5  (TRACK2)    ENI    (0)        . ERASE TRACK2 WORD                01442
      ENA    (52B)       STA 2  (TRACK)    . RESET TRACK WORD                 01443
      ISK 3  (60)        SLJ    (L+2)      .                                  01444
      ENI 3  (60)        ENI    (0)        .                                  01445
      SLJ    (8IE)       ZRO    (0)        .                                  01446

* LAUNCH CAP FROM CARRIER

1IL   LDA 1  (TRACK)     SCL    (MASK23)   . RESET                            01447
      STA 1  (TRACK)     LDQ 1  (TRACK)    .   LAUNCH BIT                     01450
      LDA    (KCNR)      ADD    (LHEAD1)   . INSERT CAP NUMBER                01451
      STA 3  (LHEAD)     ENI    (0)        .   INTO LAUNCH                    01452
      ISK 3  (60)        SLJ    (L+2)      .     COMMAND WORD                 01453
      ENI 3  (60)        ENI    (0)        .                                  01454
      SLJ    (2I)        ZRO    (0)        .     COMMAND WORD                 01455

* ORBIT ROUTINE

1IO   LDA 1  (TRACK)     SST    (MASK24)   . SET ORBIT BIT                    01456
      ENA    (52B)       STA 1  (TRACK)    . RESET TRACK WORD                 01457
      STA 1  (TRACK)     ENI    (0)        .                                  01460
      LDA    (ICRUISE)   ALS    (18)       .                                  01461
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        ADD    (LHEAD4)    ADD    (KCNR)     .                                  01462
        STA 3  (LHEAD)     ENI    (0)        . ORDER CRUISE SPEED               01463
        ISK 3  (60)        SLJ    (L+2)      .                                  01464
        ENI 3  (60)        ENI    (0)        .                                  01465
        LDA    (LEVEL)     ALS    (18)       .                                  01466
        ADD    (LHEAD3)    ADD    (KCNR)     .                                  01467
        STA 3  (LHEAD)     ENI    (0)        . ORDER CRUISE ALTITUDE            01470
        ISK 3  (60)        SLJ    (L+2)      .                                  01471
        ENI 3  (60)        ENI    (0)        .                                  01472
2IO     LDA    (LHEAD5)    ADD    (KCNR)     . ORDER ORBIT                      01473
        STA 3  (LHEAD)     ENI    (0)        .                                  01474
        ISK 3  (60)        SLJ    (L+2)      .                                  01475
        ENI 3  (60)        ENI    (0)        .                                  01476
        SLJ    (1I)        ZRO    (0)        .                                  01477

* STEER ROUTINE

1IR     LDA    (DME)       FSB    (1.)       .                                  01500
        AJP 2  (L+8)       LDA    (LHEAD8)   . JUMP IF NOT LANDED YET           01501
        ADD    (KCNR)      STA 3  (LHEAD)    . CAP LANDED,                      01502
        ENA    (0)         STA 5  (TRACK1)   .                                  01503
        STA 5  (TRACK2)    ENI    (0)        . ERASE TRACK2 WORD                01504
        ISK 3  (60)        SLJ    (L+2)      .   SCRUB TRACK                    01505
        ENI 3  (60)        ENI    (0)        .                                  01506
        SLJ    (2I)        ZRO    (0)        .   SCRUB TRACK                    01507
        LDQ 1  (TRACK)     LDL    (MASK27)   .                                  01510
        AJP 1  (8I)        ENI    (0)        . JUMP IF ALREADY STEERED          01511
        LDA 1  (ZP)        FSB    (80.)      . COMPUTE RANGE                    01512
        FMU    (.006)      FMU    (CRUISE)   .   AT WHICH TO                    01513
        FSB    (DME)       AJP 3  (L+3)      .     BEGIN LET DOWN               01514
        LDA    (LHEAD7)    ENQ    (1)        . ORDER LET DOWN                   01515
        STQ    (T+4)       SLJ-   (L+3)      .                                  01516
        LDA    (LEVEL)     ALS    (18)       .                                  01517
        ADD    (LHEAD3)    ENI    (0)        . ORDER CRUISE ALTITUDE            01520
        ADD    (KCNR)      STA 3  (LHEAD)    .                                  01521
        ISK 3  (60)        SLJ    (L+2)      .                                  01522
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        ENI 3 (60)        ENI   (0)        .                                  01523
        ENI   (0)         LDA 1 (SPD)      . COMPUTE RANGE                    01524
        FSB   (120.)      STA   (T+2)      .   AT WHICH TO                    01525
        FDV   (20.)       FMU   (T+2)      .     BEGIN DECELERATION           01526
        FSB   (DME)       AJP 3 (L+5)      .                                  01527
        LDQ   (T+4)       QJP   (L+3)      .                                  01530
        LDA 1 (TRACK)     SST   (MASK27)   . SET STEERED BIT                  01531
        STA 1 (TRACK)     ENI   (0)        .                                  01532
        LDA   (LHEAD9)    SLJ   (L+3)      . ORDER DECELERATION               01533
        LDA   (ICRUISE)   ALS   (18)       .                                  01534
        ADD   (LHEAD4)    ENI   (0)        . ORDER CRUISE SPEED               01535
        ADD   (KCNR)      STA 3 (LHEAD)    .                                  01536
        ISK 3 (60)        SLJ   (L+2)      .                                  01537
        ENI 3 (60)        ENI   (0)        .                                  01540
8I      ENA 1 (XP)        SAL   (COURSE+1).                                   01541
        ENA 1 (YP)        SAL   (COURSE+2).                                   01542
        ENA   (T+2)       SAL   (COURSE+3).                                   01543
        ENA   (0)         STA   (T+3)      .                                  01544
        ENA   (T+3)       SAL   (COURSE+4).                                   01545
        SAL   (COURSE+5)  SLJ 4 (COURSE)   .                                  01546
        ENA   (T+2)       SAL   (2IT)      . DETERMINE BEST                   01547
        LDQ 1 (IHEAD)     LDL   (7777B)    .   DIRECTION TO TURN              01550
        ARS   (12)        ENQ   (0)        .                                  01551
        DVI   (10)        STA   (T+3)      .                                  01552
        ENA   (T+3)       SAL   (3IT)      .                                  01553
        SLJ 4 (1IT)       ZRO   (0)        .                                  01554
        AJP   (2I)        AJP 3 (L+2)      . ON COURSE                        01555
        LDA   (LHEAD2)    SLJ   (L+2)      . STARBOARD TURN                   01556
        LDA   (LHEAD6)    ENI   (0)        . PORT TURN                        01557
        STA   (T+3)       LDA   (T+2)      .                                  01560
        SLJ 4 (FIX)       ZRO   (0)        .                                  01561
        ALS   (18)        ADD   (KCNR)     .                                  01562
        ADD   (T+3)       STA 3 (LHEAD)    . ORDER TURN                       01563
        ISK 3 (60)        SLJ   (L+2)      .                                  01564
        ENI 3 (60)        ENI   (0)        .                                  01565
        SLJ   (2I)        ZRO   (0)        .                                  01566
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* STATION ROUTINE

1IS   LDQ 5 (TRACK1)    LLS   (21)      .                                01567
      QRS   (39)        STQ   (IYSTA)   . UNPACK STATION Y POSITION       01570
      ENQ   (0)         LRS   (9)       .                                01571
      QRS   (39)        STQ   (IXSTA)   . UNPACK STATION X POSITION       01572
      LDA   (IXSTA)     SLJ 4 (FLOAT)   .                                01573
      STA   (XSTA)      ENI   (0)       .                                01574
      LDA   (IYSTA)     SLJ 4 (FLOAT)   .                                01575
      STA   (YSTA)      LDA 1 (YP)      . IS                             01576
      FSB   (YSTA)      STA   (T+2)     .   CAP                          01577
      ENA   (T+2)       SAL   (2ABS)    .     ON                         01600
      SLJ 4 (1ABS)      ZRO   (0)       .       STATION                  01601
      ENA   (6)         STA   (T+3)     .         .                      01602
      THS   (T+3)       SLJ   (L+6)     .           .                    01603
      LDA 1 (XP)        FSB   (XSTA)    .             .                  01604
      STA   (T+2)       ENA   (T+2)     .               .                01605
      SAL   (2ABS)      SLJ 4 (1ABS)    .                 .              01606
      THS   (T+3)       SLJ   (L+3)     . JUMP IF NOT ON STATION         01607
      LDA 1 (TRACK)     SCL   (MASK20)  . CLEAR STATION BIT              01610
      STA 1 (TRACK)     SLJ   (1IO)     . ON STATION                     01611
      LDA   (KCNR)      ADD   (LHEAD4)  . NOT ON STATION                 01612
      STA   (T+2)       LDA   (ICRUISE) .                                01613
      ALS   (18)        ADD   (T+2)     .                                01614
      STA 3 (LHEAD)     ENI   (0)       . ORDER CRUISE SPEED             01615
      ISK 3 (60)        SLJ   (L+2)     .                                01616
      ENI 3 (60)        ENI   (0)       .                                01617
      LDA   (KCNR)      ADD   (LHEAD3)  .                                01620
      STA   (T+2)       LDA   (LEVEL)   .                                01621
      ALS   (18)        ADD   (T+2)     .                                01622
      STA 3 (LHEAD)     ENI   (0)       . ORDER CRUISE ALTITUDE          01623
      ISK 3 (60)        SLJ   (L+2)     .                                01624
      ENI 3 (60)        ENI   (0)       .                                01625
      LDA 1 (XP)        FSB   (XSTA)    .                                01626
      STA   (T+2)       LDA 1 (YP)      .                                01627
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        FSB    (YSTA)       STA    (T+3)      .                                  01630
        ENA    (T+2)        SAL    (COURSE+1).  COMPUTE                          01631
        ENA    (T+3)        SAL    (COURSE+2).    COURSE                         01632
        ENA    (T+4)        SAL    (COURSE+3).      TO                           01633
        ENA    (0)          STA    (T+5)      .        STATION                   01634
        ENA    (T+5)        SAL    (COURSE+4).          .                        01635
        SAL    (COURSE+5)   SLJ 4  (COURSE)   .            .                     01636
        LDA    (T+4)        SLJ 4  (FIX)      .                                  01637
        ALS    (18)         STA    (T+4)      .  COURSE TO STATION IN T+4        01640
        LDQ 1  (IHEAD)      LDL    (7777B)    .                                  01641
        ARS    (12)         ENQ    (0)        .                                  01642
        DVI    (10)         STA    (T+3)      .                                  01643
        ENA    (T+3)        SAL    (3IT)      .                                  01644
        ENA    (T+4)        SAL    (2IT)      .                                  01645
        SLJ 4  (1IT)        ZRO    (0)        .  DETERMINE WHICH WAY TO TURN     01646
        AJP    (1I)         AJP 2  (L+2)      .  ON COURSE                       01647
        LDA    (LHEAD6)     SLJ    (L+2)      .  PORT TURN                       01650
        LDA    (LHEAD2)     ENI    (0)        .  STARBOARD TURN                  01651
        STA    (T+2)        LDA    (KCNR)     .                                  01652
        RAD    (T+2)        LDA    (T+4)      .                                  01653
        ALS    (18)         ADD    (T+2)      .  ORDER TURN TO STATION           01654
        STA 3  (LHEAD)      ENI    (0)        .                                  01655
        ISK 3  (60)         SLJ    (L+2)      .                                  01656
        ENI 3  (60)         ENI    (0)        .                                  01657
        SLJ    (1I)         ZRO    (0)        .                                  01660

*DESIGNATE TRACK ROUTINE

1J      EXF    (77411B)     SLJ    (L+3)      .  TURN OFF DESIG LT               01661
2J      ZRO    (0)          ZRO    (0)        .  HOSTILE/FRIENDLY                01662
3J      ZRO    (0)          ZRO    (0)        .  TRACK NUMBER                    01663
        LDA    (2J)         LLS    (6)        .  REPOSITION ARGUMENT             01664
        LDL    (77B)        STA    (2J)       .                                  01665
        ENA    (3J)         SLJ 4  (3J0)      .  HOOK TRACK                      01666
        LDA    (2J)         AJP    (19J)      .  SENSE OWN SHIP                  01667
        INA    (-66B)       AJP    (4J)       .  SENSE FRIENDLY                  01670
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        INA   (-2B)       AJP   (9J)       . SENSE HOSTILE                  01671
        ENA   (E6)        SLJ   (1E)       . ERROR EXIT                     01672
4J      ENA   (1)         STA   (FRIEND)   . SET FRIEND                     01673
5J      ENA   (ZN)        ADD   (3J)       . FRIEND = 1 / FRIENDLY          01674
        STA   (T+6)       LDQ 7 (T+6)      . FRIEND =-1 / HOSTILE           01675
        ENA   (TRACK)     ADD   (3J)       .                                01676
        STA   (T+6)       QJP 3 (6J)       . JUMP ACCORDING TO              01677
        QJP   (7J)        QJP 2 (8J)       .    ALTITUDE                    01700
6J      LDA   (FRIEND)    AJP 2 (L+3)      .                                01701
        ENA   (40B)       STA 7 (T+6)      . HOSTILE SUB                    01702
        SLJ   (12J)       ZRO   (0)        .                                01703
        ENA   (20B)       STA 7 (T+6)      . FRIENDLY SUB                   01704
        SLJ   (10J)       ZRO   (0)        .                                01705
7J      LDA   (FRIEND)    AJP 2 (L+3)      .                                01706
        ENA   (44B)       STA 7 (T+6)      . HOSTILE SURFACE                01707
        SLJ   (15J)       ZRO   (0)        .                                01710
        ENA   (24B)       STA 7 (T+6)      . FRIENDLY SURFACE               01711
        SLJ   (13J)       ZRO   (0)        .                                01712
8J      LDA   (FRIEND)    AJP 2 (L+3)      .                                01713
        ENA   (34B)       STA 7 (T+6)      . HOSTILE A/C                    01714
        SLJ   (18J)       ZRO   (0)        .                                01715
        ENA   (30B)       STA 7 (T+6)      . FRIENDLY A/C                   01716
        SLJ   (16J)       ZRO   (0)        .                                01717
9J      ENA   (-1)        STA   (FRIEND)   . SET HOSTILE                    01720
        SLJ   (5J)        ZRO   (0)        .                                01721
10J     LDA   (MASK14)    RAD 7 (T+6)      . SET FRIENDLY                   01722
        RAO   (FSUB)      SAU 7 (T+6)      . SET TARGET NUMBER              01723
11J     LDA   (MASK18)    RAD 7 (T+6)      . SET SUB BIT                    01724
        SLJ   (4T)        ZRO   (0)        . RETURN                         01725
12J     RAO   (HSUB)      SAU 7 (T+6)      . SET TARGET NUMBER              01726
        SLJ   (11J)       ZRO   (0)        .                                01727
13J     LDA   (MASK14)    RAD 7 (T+6)      . SET FRIENDLY                   01730
        RAO   (FSUR)      SAU 7 (T+6)      . SET TARGET NUMBER              01731
14J     LDA   (MASK17)    RAD 7 (T+6)      . SET SURFACE BIT                01732
        SLJ   (4T)        ZRO   (0)        . RETURN                         01733
15J     RAO   (HSUR)      SAU 7 (T+6)      .                                01734
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        SLJ    (14J)       ZRO    (0)        .                                  01735
16J     LDA    (MASK14)    RAD 7  (T+6)      . SET FRIENDLY                     01736
        LIL 2  (3J)        LDQ    (ITIME)    . DETERMINE TYPE INTERCEPTOR       01737
        LDL    (1B)        AJP    (L+9)      . ZERO JUMP TO F4                  01740
        LDA    (MASK8U)    RAD 7  (T+6)      . F8 TYPE                          01741
        RAO    (FAC)       LDA    (IFIG3)    . SET INITIAL                      01742
        SCL    (MASK9)     STA 2  (KFIG)     .   FUEL AND                       01743
        LDA    (ITIME)     RAD 2  (KFIG)     .     TIME                         01744
        LDA    (3J)        ALS    (42)       .                                  01745
        LIL 2  (KNR2)      STA 2  (TRACK1)   . SET UP TRACK1 WORD               01746
        RAO    (KNR2)      LDA    (FAC)      .                                  01747
        SAU 7  (T+6)       SLJ    (L+4)      . SET CAP NUMBER                   01750
        LDA    (MASK4B)    RAD 7  (T+6)      . F4 TYPE                          01751
        RAO    (FAC)       LDA    (IFIG7)    .                                  01752
        SLJ    (L-8)       ZRO    (0)        . JUMP TO INITIALIZE               01753
17J     LDA    (MASK16)    RAD 7  (T+6)      . SET A/C BIT                      01754
        SLJ    (4T)        ZRO    (0)        . RETURN                           01755
18J     RAO    (HAC)       SAU 7  (T+6)      . SET TARGET NUMBER                01756
        SLJ    (17J)       ZRO    (0)        .                                  01757
19J     ENA    (TRACK)     ADD    (3J)       .                                  01760
        STA    (T+6)       ENA    (0)        .                                  01761
        STA 7  (T+6)       LDA    (3J)       . OWN SHIP SYMBOL SET              01762
        STA    (OWN)       SLJ    (13J)      .                                  01763

* HOOK ROUTINE

3J0     SLJ    (N)         STA    (TAR)      . STORE ADDRESS OF ANSWER          01764
        LDA    (EIGHT)     FDV    (RHO)      . DETERMINE RANGE GATE             01765
        STA    (INC)       FAD    (XPIP)     .                                  01766
        STA    (XDESIG)    LDA    (INC)      . DETERMINE X POSITION             01767
        FAD    (YPIP)      STA    (YDESIG)   . DETERMINE Y POSITION             01770
        ENI 3  (1)         ENI    (0)        .                                  01771
3J1     LDA 3  (YS)        FSB    (YDESIG)   . CHECK FOR TARGET IN Y GATE       01772
        STA    (T+2)       ENA    (T+2)      .                                  01773
        SAL    (2ABS)      SLJ 4  (1ABS)     .                                  01774
        EQS    (INC)       SLJ    (L+2)      .                                  01775
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        SLJ    (L+2)        ZRO    (0)        .                                  01776
        THS    (INC)        SLJ    (3J2)      . JUMP IF NO TARGET IN GATE        01777
        LDA 3  (XS)         FSB    (XDESIG)   . CHECK FOR TARGET IN X GATE       02000
        STA    (T+2)        ENA    (T+2)      .                                  02001
        SAL    (2ABS)       SLJ 4  (1ABS)     .                                  02002
        EQS    (INC)        SLJ    (L+2)      .                                  02003
        SLJ    (L+2)        ZRO    (0)        .                                  02004
        THS    (INC)        SLJ    (3J2)      . JUMP IF NO TARGET IN GATE        02005
        SIL 3  (3J)         LDA    (3J)       .                                  02006
        STA 7  (TAR)        SLJ    (3J0)      . STORE ANSWER                     02007
3J2     ISK 3  (15)         SLJ    (3J1)      . LOOP                             02010
        ENA    (E13)        SLJ    (1E)       .                                  02011

* KEYBOARD ROUTINE ENTRY AND CHECK

1K      EXF    (77110B)     INT    (RANGE)    . INPUT RANGE SWITCH               02012
        EXF    (77001B)     LIL 5  (RANGE)    . DESLECT                          02013
        LDA 5  (RHO)        STA    (RHO)      . SET RANGE FACTOR                 02014
        EXF    (77102B)     INT    (XBALL)    . INPUT X-TRACK BALL               02015
        EXF    (77001B)     LDA    (XBALL)    . DESELECT                         02016
        ALS    (39)         ARS    (39)       . EXTEND SIGN BIT                  02017
        SLJ 4  (FLOAT)      ZRO    (0)        .                                  02020
        FDV    (RHO)        STA    (XPIP)     . RANGE SCALE X-POSITION           02021
        EXF    (77104B)     INT    (YBALL)    . INPUT Y-TRACK BALL               02022
        EXF    (77001B)     LDA    (YBALL)    . DESELECT                         02023
        ALS    (39)         ARS    (39)       . EXTEND SIGN BIT                  02024
        SLJ 4  (FLOAT)      ZRO    (0)        .                                  02025
        FDV    (RHO)        STA    (YPIP)     . RANGE SCALE Y-POSITION           02026
        LDA    (XBALL)      ALS    (36)       . ASSEMBLE HOOK WORD               02027
        ADD    (PIP)        STA    (HOOK)     .                                  02030
        LDA    (YBALL)      RAD    (HOOK)     .                                  02031
        EXF    (77010B)     EXF 7  (77010B)   . SELECT MEMORY UPDATE             02032
        OUT    (HOOK)       ENI    (0)        . OUTPUT HOOK TO DD65              02033
1K1     ENI 4  (120)        ENA    (53B)      . CHECK FOR $ IN BUF1              02034
        EQS 4  (BUF1)       SLJ    (4T)       . NO $ EXIT TO EXECUTIVE ROUTINE   02035
        SLJ    (1P)         ZRO    (0)        . JUMP TO PROGRAM CONTROL          02036
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2K      LDA   (IFLAG)      AJP 1 (2T)      . CHECK FOR BEGIN FLAG                  02037
        LDA   (BUF1+1)     AJP   (L+2)     . NOTHING IN BUF1  JUMP TO 2T           02040
        EQS   (F13)        SLJ   (1T)      . CHECK FOR B IN BUFF+1                 02041
        SLJ   (1K1)        ZRO   (0)       . YES JUMP TO 1K1                       02042

* HISTORY ROUTINE

1L      EXF   (77221B)     SLJ   (4L)      . TURN OFF HISTORY LT                   02043
2L      ZRO   (0)          ZRO   (0)       . NUMBER OF POINTS DESIRED              02044
3L1     ZRO   (0)          ZRO   (0)       . MINUTES INSTEAD OF POINTS             02045
3L      ZRO   (0)          ZRO   (0)       . TRACK DESIRED                         02046
4L      ENA   (3L)         SLJ 4 (3J0)     . HOOK TRACK                            02047
        ENA   (9)          STA   (PPM)     . SET EVERY SWEEP COUNT                 02050
        LDA   (2L)         AJP   (8L)      . JUMP IF NR POINTS = ZERO              02051
        THS   (30B)        SLJ   (L+2)     .                                       02052
        SLJ   (9L)         ZRO   (0)       . JUMP IF NR POINTS .GT. 24             02053
5L      LDA   (3L1)        AJP 5 (10L)     .                                       02054
        LAC   (HISTORY)    AJP 2 (7L)      . DETERMINE WHICH ARRAYS TO USE         02055
        LIL 2 (3L1)        LIL 4 (2L)      . HIS1 ARRAYS                           02056
        SIU 4 (13F)        SIU 4 (4G)      . SET INDEXES                           02057
        LIL 3 (3L)         SIL 3 (HIS1)    .                                       02060
        LIL 4 (PPM)        LDA 4 (PP0)     .                                       02061
        STA   (PPMC1)      STA   (PPMC)    . SET TIMING CHAINS                     02062
        ENA   (XHIS1)      SLJ 4 (1L0)     . JUMP TO FILL ROUTINE                  02063
6L      SIU 4 (10F1)       SIL 5 (10F1)    . SAVE INDEXES                          02064
        SIU 6 (11F)        ENA   (0)       .   4, 5, 6                            02065
        STA   (3L1)        STA   (2L)      . ZERO ARGUMENTS                        02066
        SLJ   (10F)        ZRO   (0)       . JUMP TO DISPLAY                       02067
7L      LIL 2 (3L1)        LIL 4 (2L)      . HIS2 ARRAYS                           02070
        SIU 4 (15F)        SIU 4 (6G)      . SET INDEXES                           02071
        LIL 3 (3L)         SIL 3 (HIS2)    .                                       02072
        LIL 4 (PPM)        LDA 4 (PP0)     .                                       02073
        STA   (PPMC2)      STA   (PPMC)    . SET TIMING CHAINS                     02074
        ENA   (XHIS2)      SLJ 4 (1L0)     . JUMP TO FILL ROUTINE                  02075
        SLJ   (6L)         ZRO   (0)       .                                       02076
8L      ENA   (12)         STA   (2L)      . PUT 12 IN 2L                          02077
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        SLJ    (5L)          ZRO    (0)        .                                  02100
9L      ENA    (24)          STA    (2L)       . PUT 24 IN 2L                     02101
        SLJ    (5L)          ZRO    (0)        .                                  02102

* TIMING CHAIN ROUTINE

10L     SLJ    (N)           ENI    (0)        . EXIT/ENTRY                       02103
        ENA    (60)          ENQ    (0)        . DETERMINE PERIODS                02104
        DVI    (IP)          STA    (PPM)      .   PER MIN                        02105
        ENQ    (0)           MUI    (2L)       . POINTS NEEDED                    02106
        STA    (3L1)         LDA    (TIME)     .                                  02107
        SUB    (TFLAG)       ENQ    (0)        .                                  02110
        DVI    (IP)          ENQ    (0)        .                                  02111
        THS    (3L1)         SLJ    (L+2)      . ENOUGH POINTS STORED             02112
        STA    (3L1)         ENI    (0)        .   NO REDUCE 3L1                  02113
        LDA    (PPM)         ENI 2  (10)       .                                  02114
        EQS 2  (PTABLE)      SLJ    (L+3)      . DETERMINE TIMING CHAIN           02115
        LDA 2  (PP0)         STA    (PPMC)     .                                  02116
        SIL 2  (PPM)         SLJ    (5L)       .                                  02117
        LDA    (PPM)         ENI 2  (10)       .                                  02120
        THS 2  (PTABLE)      SLJ    (4T)       . RETURN                           02121
        LDA 2  (PP0)         STA    (PPMC)     .                                  02122
        SIL 2  (PPM)         SLJ    (10L)      . RETURN                           02123

* FILL ARRAYS ROUTINE

1L0     SLJ    (N)           SAL    (1L1)      . EXIT/ENTRY                       02124
        INA    (25)          SAL    (1L2)      . BACK UP MEMORY                   02125
90      BACKSPACE MM                                                              02126
        IJP 2  (90)          LIL 2  (3L1)      . LOOP                             02127
        LIL 5  (2L)          ENI    (0)        .                                  02130
990     READ TAPE MM, IXH,IYH                                                     02131
        SSH    (PPMC)        SLJ    (1L3)      . FILL ARRAY                       02132
1L1     LDA 3  (IXH)         STA 5  (N)        .                                  02133
1L2     LDA 3  (IYH)         STA 5  (N)        .                                  02134
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        INI 5 (-1)          ENI   (0)          .                              02135
1L3     IJP 2 (990)         SLJ   (1L0)        . RETURN                       02136

* ERASE ROUTINE

1MER    SLJ   (N)           SIU 4 (2MER)       . EXIT/ENTRY                   02137
        ENI 4 (2)           ENI   (0)          . SET INDEX FOR LOOP           02140
        EXF   (02000B)      EXF   (04001B)     . STOP RT CLOCK  DISALLOW      02141
        EXF   (77010B)      OUT   (ERASE)      . FIRST ERASE WORD             02142
        EXF   (77010B)      OUT   (S6C)        . STRING ERASE WORDS           02143
        ISK 4 (398)         SLJ   (L-1)        . LOOP                         02144
        EXF   (04000B)      EXF   (01000B)     . ALLOW  START RT CLOCK        02145
2MER    ENI 4 (N)           SLJ   (1MER)       . RETURN                       02146

* MESSAGE ROUTINE

1MSG    SLJ   (N)           STA   (T+8)        . EXIT/ENTRY                   02147
        ENA   (XP1)         SAL   (PRINT+1)    . SET UP ARGUMENTS FOR PRINT   02150
        ENA   (YMSG)        SAL   (PRINT+2)    .                              02151
        SIU 5 (2MSG)        LIL 5 (PRO)        .                              02152
        SIL 5 (PRINT+3)     LIL 5 (ADD)        .                              02153
        SIL 5 (PRINT+4)     ENQ   (0B)         .                              02154
        LDA   (T+8)         SLJ 4 (PRINT)      . JUMP TO PRINT                02155
        LIL 5 (PRINT+4)     SIL 5 (ADD)        . RESET ADD                    02156
        ENA   (-12B)        RAD   (YMSG)       . DECREASE YMSG                02157
2MSG    ENI 5 (N)           SLJ   (1MSG)       . RETURN                       02160

* GRAPH TITLE UPDATE

1N      SLJ   (*)           LDA   (GTIME)      .                              02161
        ADD   (R3)          STA   (TITLE9)     . STORE                        02162
        STA   (TITLE21)     LDA   (TFLAG)      .   INITIAL TIME               02163
        ENQ   (0)           DVI   (60)         .                              02164
        STQ   (T+10)        SLJ 4 (1NUM)       .                              02165
        ALS   (30)          SCL   (MASK37)     .                              02166
        ADD   (R4)          STA   (T+9)        . STORE FINAL                  02167
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        LDA    (T+10)       ENQ    (0)        .   INTEGER TIME                  02170
        MUI    (10)         ENQ    (0)        .                                 02171
        DVI    (60)         SLJ 4  (1NUM)     .                                 02172
        ALS    (18)         SCL    (MASK38)   .                                 02173
        RAD    (T+9)        STA    (TITLE10)  . STORE FINAL                     02174
        STA    (TITLE22)    SCL    (MASK39)   .   DECIMAL TIME                  02175
        STA    (GTIME)      SLJ    (1N)       .                                 02176

* OCTAL TO BCD NUMBER CONVERTER 0 TO 9,999,999

1NUM    SLJ    (N)          SIU 2  (3NUM)     . EXIT/ENTRY                      02177
        ENI 2  (N)          ENI    (0)        .                                 02200
        THS    (1000000)    INI 2  (1)        .                                 02201
        THS    (100000)     INI 2  (1)        . TAKES OCTAL NUMBER              02202
        THS    (10000)      INI 2  (1)        .   CONVERTS IT TO BCD            02203
        THS    (1000)       INI 2  (1)        .     AND PACKS IT IN THE         02204
        THS    (100)        INI 2  (1)        .       LOWER 36 BITS OF          02205
        THS    (10)         INI 2  (1)        .         T WITH THE REST         02206
        LDQ    (TITLE6)     STQ    (T)        .             OF THE WORD BLANKS  02207
        ENQ    (0)          DVI 2  (R0)       .                                 02210
        SAL    (2NUM)       LIL 1  (2NUM)     .                                 02211
        LDA    (T)          ALS    (6)        .                                 02212
        SCL    (77B)        ADD 1  (F0)       . I. E.                           02213
        STA    (T)          LLS    (48)       .   2020NNNNNNNNNNNNB             02214
        IJP 2  (L-5)        LDA    (T)        . LOOP                            02215
3NUM    ENI 2  (N)          SLJ    (1NUM)     . RETURN                          02216
2NUM    ZRO    (0)          ZRO    (0)        .                                 02217

* PROGRAM CONTROL ROUTINE

1P      LIL 4  (KNR)        ENI    (0)        . SET B4 = KNR                    02220
        LDA 4  (BUF1)       ENI 1  (26)       . CHECK TO SEE IF FIRST           02221
        EQS 1  (F12)        SLJ    (2P)       .   CHARACTER IS LETTER           02222
        ENA    (0)          STA    (T)        .                                 02223
        LDA 4  (BUF1)       ENI 1  (36)       .                                 02224
        EQS 1  (F0)         SLJ    (L+4)      . ASSEMBLE NAME                   02225
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        LDA    (T)        ALS    (6)        .                                  02226
        ADD 4  (BUF1)     STA    (T)        .                                  02227
        INI 4  (1)        SLJ    (L-4)      .                                  02230
        SUB    (F56)      AJP    (L-1)      .                                  02231
        LDA    (T)        ENQ    (0)        . POSITION NAME                    02232
        LRS    (6)        AJP 1  (L)        .                                  02233
        LDL    (-0B)      LIL 3  (NPROG)    .                                  02234
        EQS 3  (P0)       SLJ    (2P)       .                                  02235
        LDA 3  (0Z)       SAU    (L+7)      .                                  02236
        SAL    (4P)       ARS    (24)       .                                  02237
        STA    (5P)       SLJ 4  (3P)       . PROCESS ARGUMENTS                02240
        ENA    (1)        STA    (KNR)      .                                  02241
        STA    (KNR1)     ENI    (0)        .                                  02242
        ENA    (0)        ENI 4  (120)      . CLEAR BUFFER                     02243
        STA 4  (BUF1)     IJP 4  (L)        . LOOP                             02244
        SLJ    (N)        ZRO    (0)        . EXECUTE PROGRAM                  02245
2P      SLJ 4  (13P)      ZRO    (0)        .                                  02246
        ENA    (E0)       SLJ    (1E)       . PROGRAM NOT CALLED               02247
3P      SLJ    (N)        SLJ    (L+3)      . PROCESS ARGUMENTS                02250
4P      ZRO    (0)        ZRO    (0)        . NEXT ARGUMENT ADDRESS            02251
5P      ZRO    (0)        ZRO    (0)        . NUMBER OF ARGUMENTS              02252
6P      LDA 4  (BUF1)     AJP    (8P)       .                                  02253
        INA    (-33B)     AJP    (L+5)      . SENSE COMMA OR OPEN PAREN        02254
        INA    (-1B)      AJP    (L+4)      .                                  02255
        INA    (-37B)     AJP    (3P)       . SENSE PERIOD OR CLOSE PAREN      02256
        INA    (-1)       AJP    (3P)       .                                  02257
        SLJ    (8P)       ZRO    (0)        .                                  02260
        INI 4  (1)        LDA 4  (BUF1)     . SKIP SPACES                      02261
        SUB    (F56)      AJP    (L-1)      .                                  02262
        ENA    (0)        STA    (T)        .                                  02263
        LDA 4  (BUF1)     ENI 1  (10)       .                                  02264
        EQS    (F53)      SLJ    (L+3)      . SENSE MINUS SIGN                 02265
        STA    (NEG)      INI 4  (1)        . SET NEGATIVE FLAG                02266
        LDA 4  (BUF1)     SLJ    (L+3)      .                                  02267
        EQS    (60B)      SLJ    (L+2)      . SENSE PLUS SIGN                  02270
        INI 4  (1)        LDA 4  (BUF1)     .                                  02271
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        EQS 1 (F0)      SLJ   (L+2)    . SENSE OCTAL NUMBER                02272
        SLJ   (9P)      ZRO   (0)      . ASSEMBLE NUMBER                   02273
        LDA 4 (BUF1)    ENI 1 (36)     .                                   02274
        EQS 1 (F0)      SLJ   (L+4)    .                                   02275
        LDA   (T)       ALS   (6)      . ASSEMBLE NAME                     02276
        ADD 4 (BUF1)    STA   (T)      .                                   02277
        INI 4 (1)       SLJ   (L-4)    . LOOP                              02300
        SUB   (F56)     AJP   (L-1)    .                                   02301
        LDA   (T)       ENQ   (0)      . POSITION ARGUMENT                 02302
        LRS   (6)       AJP 1 (L)      .                                   02303
        STQ   (T)       ENI   (0)      .                                   02304
7P      RAO   (4P)      RSO   (5P)     .                                   02305
        AJP 3 (8P)      LDA   (T)      . SENSE ARGUMENT LIMIT              02306
        LDQ   (NEG)     QJP   (L+3)    . CHECK NEGATIVE FLAG               02307
        LAC   (T)       ENQ   (0)      .                                   02310
        STQ   (NEG)     ENI   (0)      .                                   02311
        STA 7 (4P)      SLJ   (6P)     . LOOP                              02312
8P      SLJ 4 (13P)     ZRO   (0)      .                                   02313
        ENA   (E3)      SLJ   (1E)     . TOO MANY ARGUMENTS                02314
9P      SIL 4 (10P)     SLJ   (L+2)    .                                   02315
10P     ZRO   (0)       ZRO   (0)      . PRESENT POSITION IN ARRAY         02316
        LIL 2 (10P)     ENI 5 (0)      . DETERMINE WIDTH OF NUMBER         02317
        LDA 2 (BUF1)    ENI   (0)      .                                   02320
        INA   (-33B)    AJP   (11P)    . SENSE COMMA                       02321
        INA   (-01B)    AJP   (11P)    . SENSE OPEN PAREN                  02322
        INA   (-37B)    AJP   (11P)    . SENSE PERIOD                      02323
        INA   (-01B)    AJP   (11P)    . SENSE CLOSING PAREN               02324
        INI 2 (1)       INI 5 (1)      . B5 NOW HAS WIDTH OF NUMBER        02325
        SLJ   (L-6)     ZRO   (0)      .                                   02326
11P     ENA   (0)       STA   (T)      .                                   02327
        ENI 1 (10)      SLJ 4 (12P)    .                                   02330
        EQS 1 (F0)      SLJ   (2P)     . SENSE OCTAL NUMBER                02331
        LDA   (T)       MUI   (F0)     . MULTIPLY BY TEN                   02332
        INA 1 (0)       STA   (T)      . INCREASE BY NEXT DIGIT            02333
        SLJ   (L-4)     ZRO   (0)      . LOOP                              02334
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* DETERMINE OCTAL NUMBER ROUTINE

12P   SLJ    (N)          IJP 5 (L+2)     . EXIT/ENTRY                        02335
      SLJ    (7P)         ZRO   (0)       .                                   02336
      LDA 4  (BUF1)       SAL   (L+3)     .                                   02337
      EQS    (F56)        SLJ   (L+2)     . CHECK FOR SPACES                  02340
      LDA    (F0)         SAL   (L+1)     . PUT ZEROS IN FOR SPACES           02341
      INI 4  (1)          ENA   (N)       .                                   02342
      SLJ    (12P)        ZRO   (0)       . RETURN                            02343

* ZERO OUT BUF1 UPON ERROR ROUTINE

13P   SLJ    (N)          LIL 4 (KNR1)    . EXIT/ENTRY                        02344
      ENA    (0)          STA 4 (BUF1)    . ZERO OUT BUF1                     02345
      IJP 4  (L-1)        SLJ   (13P)     . RETURN                            02346

* HOLD OR PAUSE ROUTINE

1PQ   LDA    (TIME)       STA   (PAUSE)   . STORE TIME                        02347
      ENA    (1)          STA   (PFLAG)   . SET P-FLAG                        02350
      LDA    (PFLAG)      AJP 1 (L)       . WAIT LOOP                         02351
      EXF    (77303B)     LDA   (PAUSE)   . TURN OFF PAUSE LIGHT              02352
      STA    (TIME)       STA   (ITIME)   . RESTORE TIME                      02353
      SLJ    (4T)         ZRO   (0)       . RETURN                            02354

* INTERCEPT COMMAND ROUTINE

1Q    EXF    (77321B)     SLJ   (L+3)     . TURN OFF INT LIGHT                02355
2Q    ZRO    (0)          ZRO   (0)       . CAP NR OF INTECPTOR               02356
3Q    ZRO    (0)          ZRO   (0)       . BOGEY HOOKED                      02357
      ENA    (3Q)         SLJ 4 (3J0)     . HOOK BOGEY                        02360
      ENI 2  (1)          ENI   (0)       . SET INDEX FOR LOOP                02361
      SSK 2  (TRACK)      SLJ   (L+6)     . SENSE FRIENDLY                    02362
      LDA    (MASK16)     LDQ 2 (TRACK)   .                                   02363
      MEQ    (MASK16)     SLJ   (L+5)     . CHECK FOR A/C BIT                 02364
      QRS    (24)         LDL   (77B)     .                                   02365
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        EQS    (2Q)        SLJ    (L+2)      . IS CAP CALLED FOR AIRBORNE      02366
        SIU 2  (2Q)        SLJ    (4Q)       . YES JUMP TO 4Q                  02367
        ISK 2  (15)        SLJ    (L-6)      . LOOP                            02370
        ENI 2  (16)        LDQ    (MASK11)   . LAUNCH CAP ROUTINE              02371
        ENA    (52B)       ENI    (0)        .                                 02372
        MEQ 2  (TRACK)     SLJ    (5Q)       . CHECK FOR NON ACTIVE TRACKS     02373
        ENA    (2Q)        SLJ 4  (1X1)      . GET CAP NUMBER                  02374
        LDA    (2Q)        ALS    (24)       .                                 02375
        RAD 2  (TRACK)     ENI    (0)        . SET CAP NUMBER                  02376
        LDA    (MASK14)    RAD 2  (TRACK)    . SET FRIENDLY SYMBOL             02377
        LDA    (MASK4B)    RAD 2  (TRACK)    . SET TYPE INTERCEPTOR            02400
        LDA    (MASK23)    RAD 2  (TRACK)    . SET LAUNCH BIT                  02401
        SIU 2  (2Q)        LDA    (IFIG7)    . STORE CAP TRACK NR              02402
        SCL    (MASK9)     STA 2  (KFIG)     . INITIALIZE FUEL                 02403
        LDA    (ITIME)     RAD 2  (KFIG)     .   AND LAUNCH TIME               02404
4Q      LDA    (MASK19)    RAD 2  (TRACK)    . SET INTERCEPT BIT               02405
        LDQ    (2Q)        QRS    (24)       .                                 02406
        LDL    (77B)       ALS    (42)       .                                 02407
        SLJ 4  (6Q)        ZRO    (0)        . JUMP TO DETERMINE TRACK1 WORD   02410
        LIL 3  (8Q)        STA    (T+2)      .                                 02411
        LDA 3  (TRACK1)    SCL    (MASK36)   .                                 02412
        ADD    (T+2)       STA 3  (TRACK1)   . SET UP TRACK1 WORD              02413
        LDQ 2  (TRACK)     LDL    (MASK10)   .                                 02414
        STA 2  (TRACK)     ENA    (55B)      . SET ENAGAGED CAP SYMBOL         02415
        RAD 2  (TRACK)     LIL 2  (3Q)       .                                 02416
        LDQ 2  (TRACK)     LDL    (MASK10)   .                                 02417
        STA 2  (TRACK)     ENA    (54B)      . SET ENGAGED BOGEY SYMBOL        02420
        RAD 2  (TRACK)     ENI    (0)        .                                 02421
        LDA    (3Q)        ALS    (36)       .                                 02422
        RAD 3  (TRACK1)    ENA    (0)        .                                 02423
        STA    (2Q)        SLJ    (4T)       .                                 02424
5Q      ENA    (E56)       SLJ 4  (1MSG)     . NO CAP AVAILABLE                02425
        ENA    (0)         STA    (2Q)       .   TO BE LAUNCHED                02426
        SLJ    (4T)        ZRO    (0)        .                                 02427
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* DETERMINE WHICH TRACK1 WORD TO USE

6Q      SLJ   (N)          SIL 4 (7Q)       . EXIT/ENTRY                          02430
        LIL 4 (KNR2)       LDQ   (MASK36)   .                                     02431
        MEQ 4 (TRACK1)     SLJ   (L+3)      . CHECK FOR CAP TRACK NR              02432
7Q      SIL 4 (8Q)         ENI 4 (N)        . SAVE TRACK1 INDEX                   02433
8Q      SLJ   (6Q)         ZRO   (0)        . RETURN                              02434
        LIL 4 (KNR2)       SIL 4 (8Q)       . USE NEXT TRACK1 WORD                02435
        STA   (9Q)         RAO   (KNR2)     . INCREASE KNR2                       02436
        LDA   (9Q)         SLJ   (7Q)       . RETURN                              02437
9Q      ZRO   (0)          ZRO   (0)        .                                     02440

* DROP HISTORY ROUTINE

1R      EXF   (77321B)     SLJ   (3R)       . TURN OFF DROP LT                    02441
2R      ZRO   (0)          ZRO   (0)        . TRACK TO BE DROPPED                 02442
3R      ENA   (2R)         SLJ 4 (3J0)      . HOOK TRACK                          02443
        EQS   (HIS1)       SLJ   (4R)       . HIS1  NO  --JUMP  4R                02444
        ENA   (0)          STA   (HIS1)     . RESET HIS1                          02445
        ENA   (-0B)        STA   (HISTORY)  . RESET HISTORY                       02446
        SLJ   (4T)         ZRO   (0)        . RETURN                              02447
4R      EQS   (HIS2)       SLJ   (4T)       . HIS2  NO  --JUMP  4T                02450
        ENA   (0)          STA   (HIS2)     . RESET HSI2                          02451
        STA   (HISTORY)    SLJ   (4T)       . RESET HISTORY    RETURN             02452

* STOP AND CRITIQUE ROUTINE

1S      EXF   (77403B)     ENA   (0)        . TURN OFF STOP LT                    02453
        STA   (NPTS)       STA   (NTRACKS)  . SET NPTS AND NTRACKS        =0     02454
        ENA   (1)          STA   (MOD)      . SET MOD                     =1     02455
        ENI 6 (1)          LIL 3 (NTRACKS)  . SET INDEXES                         02456
        ENA   (E68)        SLJ 4 (1MSG)     . GRAPH BEING PLOTTED MSG             02457
9991    BACKSPACE MM                                                              02460
        READ TAPE MM, XN,YN,ZN, TFLAG                                             02461
        SLJ 4 (1N)         ZRO   (0)        . UPDATE GRAPH TITLE                  02462
        LDA   (TFLAG)      SUB   (MTIME)    . DETERMINE IF THIS GRAPH             02463
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        AJP 6 (12S1)        ENI   (0)          .   WILL EXCEED MAX TIME          02464
91      REWIND MM                                                                 02465
        RAO   (NTRACKS)     LIL 3 (NTRACKS)    . INCREASE NTRACKS                 02466
991     READ TAPE MM, XN,YN,ZN,JTIME                                              02467
        LDA 3 (XN)          AJP 1 (L+3)        . IS X ZERO  NO JUMP               02470
        LDA 3 (YN)          AJP 1 (L+2)        . IS Y ZERO  NO JUMP               02471
        SLJ   (4S1)         ZRO   (0)          . BOTH X AND Y ZERO  JUMP          02472
        LDA 3 (ZN)          AJP 7 (13S1)       . JUMP IF SUBMARINE                02473
        STA 6 (Y)           LDA   (JTIME)      . STORE Z DATA                     02474
        SUB   (FTIME)       SLJ 4 (FLOAT)      . CHANGE TIME TO MIN               02475
        FDV   (60.)         STA 6 (X)          . STORE TIME                       02476
        RAO   (NPTS)        LDA   (JTIME)      . INCREASE NPTS                    02477
        SUB   (TFLAG)       AJP   (5S1)        . MORE TIME  NO JUMP               02500
        AJP 2 (5S1)         ENA   (1603B)      . MORE POINTS  YES JUMP            02501
        THS   (NPTS)        SLJ   (6S1)        .                                  02502
2S11    ENA   (NPTS)        SAL   (DRAW+1)     . FILL DRAW ARGUMENTS              02503
        ENA   (X)           SAL   (DRAW+2)     .                                  02504
        ENA   (Y)           SAL   (DRAW+3)     .                                  02505
        ENA   (MOD)         SAL   (DRAW+4)     .                                  02506
        ENA   (S1C)         SAL   (DRAW+5)     .                                  02507
        ENA   (LABLE)       SAL   (DRAW+6)     .                                  02510
        ENA   (ITITLE)      SAL   (DRAW+7)     .                                  02511
        ENA   (XSCALE1)     SAL   (DRAW+8)     .                                  02512
        ENA   (YSCALE1)     SAL   (DRAW+9)     .                                  02513
        ENA   (IXUP1)       SAL   (DRAW+10)    .                                  02514
        ENA   (IYRT1)       SAL   (DRAW+11)    .                                  02515
        ENA   (MODXAX1)     SAL   (DRAW+12)    .                                  02516
        ENA   (MODYAX1)     SAL   (DRAW+13)    .                                  02517
        ENA   (IWIDE1)      SAL   (DRAW+14)    .                                  02520
        ENA   (IHIGH1)      SAL   (DRAW+15)    .                                  02521
        ENA   (IGRID)       SAL   (DRAW+16)    .                                  02522
        ENA   (LAST)        SAL   (DRAW+17)    .                                  02523
        SLJ 4 (DRAW)        ZRO   (0)          . JUMP TO DRAW                     02524
        ENI 5 (300)         ENA   (0)          . CLEAR ARRAY                      02525
        STA 5 (X)           STA 5 (Y)          .                                  02526
        IJP 5 (L-1)         ENI   (0)          . LOOP                             02527
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        LDA    (LAST)       AJP 1 (7S1)     . CHECK TO SEE IF GOOD GRAPH      02530
2S12    ENA    (3)          ENI   (0)       . IS MOD = 3                      02531
        EQS    (MOD)        SLJ   (L+2)     .                                 02532
3S1     SLJ    (1S1)        ZRO   (0)       .   YES JUMP TO X-Y PLOT          02533
        ENA    (2)          STA   (MOD)     . SET MOD = 2                     02534
        ENA    (0)          STA   (NPTS)    . SET NPTS TO ZERO                02535
        LDA    (JTIME)      SUB   (TFLAG)   . MORE TIME                       02536
        AJP    (9S1)        AJP 2 (9S1)     .   NO JUMP TO REWIND             02537
        ENI 6  (1)          SLJ   (991)     .   YES JUMP TO READ              02540
4S1     ENA    (2)          ENI   (0)       . IS NPTS .GT. 2                  02541
        THS    (NPTS)       SLJ   (10S1)    . NO - IGNORE GRAPH               02542
        LDA    (JTIME)      SUB   (TFLAG)   .   AND JUMP TO READ              02543
        AJP    (5S1)        AJP 2 (5S1)     . MORE TIME  NO JUMP              02544
        SLJ    (2S11)       ZRO   (0)       .   YES JUMP TO GRAPH             02545
5S1     ENA    (15)         ENI   (0)       . CHECK FOR LAST TRACK            02546
        EQS    (NTRACKS)    SLJ   (11S1)    . LAST TRACK   NO JUMP            02547
        ENA    (3)          STA   (MOD)     .   YES SET MOD = 3               02550
        SLJ    (2S11)       ZRO   (0)       . JUMP TO GRAPH                   02551
6S1     INI 6  (1)          SLJ   (991)     . INCREASE INDEX  JUMP TO READ    02552
7S1     LDA    (LAST)       SUB   (2B)      . LAST = 2                        02553
        AJP 1  (2S12)       STA   (NPTS)    .   NO JUMP TO MOD CHECK          02554
        ENA    (1)          STA   (MOD)     . RESET NPTS AND MOD              02555
        ENI 6  (1)          LDA   (JTIME)   .   AND INDEX                     02556
        SUB    (TFLAG)      AJP   (991)     . MORE TIME                       02557
        AJP 2  (991)        SLJ   (91)      .   YES JUMP TO REWIND            02560
8S1     SLJ    (1S1)        ZRO   (0)       .   NO JUMP TO X-Y POSIT PLOT     02561
9S1     ENA    (0)          STA   (NPTS)    . RESET NPTS                      02562
        ENI 6  (1)          SLJ   (91)      . RESET INDEX  JUMP TO REWIND     02563
10S1    ENA    (0)          STA   (NPTS)    . RESET NPTS AND INDEX            02564
        ENI 6  (1)          SLJ   (991)     . JUMP TO READ                    02565
11S1    ENA    (2)          ENI   (0)       . NPTS .GT. TWO                   02566
        THS    (NPTS)       SLJ   (9S1)     .   NO JUMP TO GRAPH              02567
        SLJ    (2S11)       ZRO   (0)       .   YES JUMP TO GRAPH             02570
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* RESET BASE TIME ROUTINE

12S1  SLJ   (N)          LDA   (JTIME)    . EXIT/ENTRY                          02571
      STA   (FTIME)      ENA   (1800)     . SET FTIME TO LAST JTIME             02572
      RAD   (MTIME)      SLJ   (12S1)     . INCREASE MAX TIME  RETURN           02573

*SCALE SUBMARINE DEPTH ROUTINE

13S1  SLJ   (N)          FMU   (SCALE)    . EXIT/ENTRY                          02574
      SLJ   (13S1)       ZRO   (0)        . SCALE   RETURN                      02575

* X-Y PLOT ROUTINE

1S1   LIL 3 (PPI)        ENI 6 (1)        . SET INDEXES                         02576
      ENA   (0)          STA   (NPTS)     . SET NPTS                    =0      02577
      ENA   (1)          STA   (MOD)      . RESET MOD TO ONE                    02600
1S2   LDA 3 (X1)         AJP 1 (L+3)      . IS X ZERO   NO JUMP                 02601
      LDA 3 (Y1)         AJP 1 (L+2)      . IS Y ZERO   NO JUMP                 02602
      SLJ   (L+5)        ZRO   (0)        . BOTH X AND Y ZERO JUMP              02603
      LDA 3 (X1)         STA 6 (X)        . STORE X DATA                        02604
      LDA 3 (Y1)         STA 6 (Y)        . STORE Y DATA                        02605
      ISK 6 (30)         SLJ   (L+2)      . CHECK FOR NPTS = 30                 02606
      SLJ   (1S3)        ZRO   (0)        . JUMP TO GRAPH                       02607
      IJP 3 (1S2)        SIL 6 (NPTS)     .                                     02610
      SLJ   (L+2)        ZRO   (0)        .                                     02611
1S3   ENA   (30)         STA   (NPTS)     . SET NPTS EQUAL TO THIRTY            02612
      ENA   (NPTS)       SAL   (DRAW+1)   . FILL DRAW ARGUMENTS                 02613
      ENA   (X)          SAL   (DRAW+2)   .                                     02614
      ENA   (Y)          SAL   (DRAW+3)   .                                     02615
      ENA   (MOD)        SAL   (DRAW+4)   .                                     02616
      ENA   (F5)         SAL   (DRAW+5)   .                                     02617
      ENA   (LABLE)      SAL   (DRAW+6)   .                                     02620
      ENA   (KTITLE)     STA   (DRAW+7)   .                                     02621
      ENA   (XSCALE)     SAL   (DRAW+8)   .                                     02622
      ENA   (YSCALE)     SAL   (DRAW+9)   .                                     02623
      ENA   (IXUP)       SAL   (DRAW+10)  .                                     02624
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        ENA    (IYRIGHT)   SAL    (DRAW+11) .                                  02625
        ENA    (MODEXAX)   SAL    (DRAW+12) .                                  02626
        ENA    (MODEYAX)   SAL    (DRAW+13) .                                  02627
        ENA    (IWIDE)     SAL    (DRAW+14) .                                  02630
        ENA    (IHIGH)     SAL    (DRAW+15) .                                  02631
        ENA    (IGRID)     SAL    (DRAW+16) .                                  02632
        ENA    (LAST)      SAL    (DRAW+17) .                                  02633
        SLJ 4  (DRAW)      ZRO    (0)       . JUMP TO DRAW                     02634
        ENI 5  (50)        ENA    (0)       . CLEAR ARRAY                      02635
        STA 5  (X)         STA 5  (Y)       .                                  02636
        IJP 5  (L-1)       LDA    (LAST)    . LOOP                             02637
        EQS    (2B)        SLJ    (L+4)     . CHECK FOR LAST EQUAL TWO         02640
        ENA    (1)         STA    (MOD)     . SET MOD EQUAL ONE                02641
        ENI 6  (1)         IJP 3  (1S2)     . RESET INDEX CHECK MORE POINTS    02642
        LIL 3  (PPI)       SLJ    (1S4)     . NO RESET INDEX  JUMP NEXT PLOT   02643
        ENA    (2)         STA    (MOD)     . SET MOD EQUAL TWO                02644
        ENI 6  (1)         IJP 3  (1S2)     . CHECK FOR MORE POINTS            02645
        LIL 3  (PPI)       ENI    (0)       .                                  02646
1S4     LDA 3  (X2)        AJP 1  (L+3)     . IS X ZERO  NO JUMP               02647
        LDA 3  (Y2)        AJP 1  (L+2)     . IS Y ZERO  NO JUMP               02650
        SLJ    (L+5)       ZRO    (0)       . BOTH X AND Y ZERO JUMP           02651
        LDA 3  (X2)        STA 6  (X)       . STORE X DATA                     02652
        LDA 3  (Y2)        STA 6  (Y)       . STORE Y DATA                     02653
        ISK 6  (30)        SLJ    (L+2)     . CHECK FOR NPTS = 30              02654
        SLJ    (1S5)       ZRO    (0)       . JUMP TO GRAPH                    02655
        IJP 3  (1S4)       SIL 6  (NPTS)    .                                  02656
        SLJ    (L+2)       ZRO    (0)       .                                  02657
1S5     ENA    (30)        STA    (NPTS)    . SET NPTS EQUAL TO THIRTY         02660
        ENA    (NPTS)      SAL    (DRAW+1)  . FILL DRAW ARGUMENTS              02661
        ENA    (X)         SAL    (DRAW+2)  .                                  02662
        ENA    (Y)         SAL    (DRAW+3)  .                                  02663
        ENA    (MOD)       SAL    (DRAW+4)  .                                  02664
        ENA    (F1)        SAL    (DRAW+5)  .                                  02665
        ENA    (LABLE)     SAL    (DRAW+6)  .                                  02666
        ENA    (KTITLE)    STA    (DRAW+7)  .                                  02667
        ENA    (XSCALE)    SAL    (DRAW+8)  .                                  02670
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        ENA    (YSCALE)     SAL    (DRAW+9)  .
        ENA    (IXUP)       SAL    (DRAW+10) .
        ENA    (IYRIGHT)    SAL    (DRAW+11) .
        ENA    (MODEXAX)    SAL    (DRAW+12) .
        ENA    (MODEYAX)    SAL    (DRAW+13) .
        ENA    (IWIDE)      SAL    (DRAW+14) .
        ENA    (IHIGH)      SAL    (DRAW+15) .
        ENA    (IGRID)      SAL    (DRAW+16) .
        ENA    (LAST)       SAL    (DRAW+17) .
        SLJ 4  (DRAW)       ZRO    (0)       . JUMP TO DRAW
        ENI 5  (50)         ENA    (0)       . CLEAR ARRAY
        STA 5  (X)          STA 5  (Y)       .
        IJP 5  (L-1)        LDA    (LAST)    . LOOP
        EQS    (2B)         SLJ    (L+5)     . CHECK FOR LAST EQUAL TWO
        ENA    (1)          STA    (MOD)     . RESET MOD EQUAL ONE
        ENI 6  (1)          IJP 3  (1S4)     . CHECK FOR MORE POINTS
        ENA    (1)          STA    (PPI)     . RESET PPI TO ONE
        SLJ    (L+4)        ZRO    (0)       .
        ENA    (1)          STA    (MOD)     . SET MOD
        ENI 6  (1)          IJP 3  (1S4)     . CHECK FOR MORE POINTS
        SLJ    (L-4)        ZRO    (0)       .
        ENA    (0)          STA    (NPTS)    .
        STA    (NTRACKS)    LIL 3  (NTRACKS) .
9       REWIND MM
        RAO    (NTRACKS)    LIL 3  (NTRACKS) . INCREASE NTRACKS
99      READ TAPE MM, XN,YN,ZN,JTIME
        LDA 3  (XN)         AJP 1  (L+3)     . IS X ZERO  NO JUMP
        LDA 3  (YN)         AJP 1  (L+2)     . IS Y ZERO  NO JUMP
        SLJ    (4S)         ZRO    (0)       . BOTH X AND Y ZERO  JUMP
        LDA 3  (XN)         STA 6  (X)       . STORE X DATA
        LDA 3  (YN)         STA 6  (Y)       . STORE Y DATA
        RAO    (NPTS)       LDA    (JTIME)   . INCREASE NPTS
        SUB    (TFLAG)      AJP    (5S)      . MORE TIME  NO JUMP
        AJP 2  (5S)         ENA    (1603B)   . MORE POINTS  YES JUMP
        THS    (NPTS)       SLJ    (6S)      .
2S      ENA    (NPTS)       SAL    (DRAW+1)  . FILL DRAW ARGUMENTS
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        ENA    (X)          SAL    (DRAW+2)  .                                  02735
        ENA    (Y)          SAL    (DRAW+3)  .                                  02736
        ENA    (MOD)        SAL    (DRAW+4)  .                                  02737
        ENA    (S1C)        SAL    (DRAW+5)  .                                  02740
        ENA    (LABLE)      SAL    (DRAW+6)  .                                  02741
        ENA    (KTITLE)     STA    (DRAW+7)  .                                  02742
        ENA    (XSCALE)     SAL    (DRAW+8)  .                                  02743
        ENA    (YSCALE)     SAL    (DRAW+9)  .                                  02744
        ENA    (IXUP)       SAL    (DRAW+10) .                                  02745
        ENA    (IYRIGHT)    SAL    (DRAW+11) .                                  02746
        ENA    (MODEXAX)    SAL    (DRAW+12) .                                  02747
        ENA    (MODEYAX)    SAL    (DRAW+13) .                                  02750
        ENA    (IWIDE)      SAL    (DRAW+14) .                                  02751
        ENA    (IHIGH)      SAL    (DRAW+15) .                                  02752
        ENA    (IGRID)      SAL    (DRAW+16) .                                  02753
        ENA    (LAST)       SAL    (DRAW+17) .                                  02754
        SLJ 4  (DRAW)       ZRO    (0)       . JUMP TO DRAW                     02755
        ENI 5  (600)        ENA    (0)       . CLEAR ARRAY                      02756
        STA 5  (X)          STA 5  (Y)       .                                  02757
        IJP 5  (L-1)        ENI    (0)       . LOOP                             02760
        LDA    (LAST)       AJP 1  (7S)      . CHECK TO SEE IF GOOD GRAPH       02761
2S1     ENA    (3)          ENI    (0)       . IS MOD = 3                       02762
        EQS    (MOD)        SLJ    (L+2)     .                                  02763
3S      SLJ    (1END)       ZRO    (0)       .   YES JUMP TO X-Y PLOT           02764
        ENA    (2)          STA    (MOD)     . SET MOD = 2                      02765
        ENA    (0)          STA    (NPTS)    . SET NPTS TO ZERO                 02766
        LDA    (JTIME)      SUB    (TFLAG)   . MORE TIME                        02767
        AJP    (9S)         AJP 2  (9S)      .   NO JUMP TO REWIND              02770
        ENI 6  (1)          SLJ    (99)      .   YES JUMP TO READ               02771
4S      ENA    (2)          ENI    (0)       . IS NPTS .GT. 2                   02772
        THS    (NPTS)       SLJ    (10S)     . NO - IGNORE GRAPH                02773
        LDA    (JTIME)      SUB    (TFLAG)   .   AND JUMP TO READ               02774
        AJP    (5S)         AJP 2  (5S)      . MORE TIME  NO JUMP               02775
        SLJ    (2S)         ZRO    (0)       .   YES JUMP TO GRAPH              02776
5S      ENA    (15)         ENI    (0)       . CHECK FOR LAST TRACK             02777
        EQS    (NTRACKS)    SLJ    (11S)     . LAST TRACK NO JUMP               03000
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        ENA    (3)          STA    (MOD)      .   YES SET MOD = 3                  03001
        SLJ    (2S)         ZRO    (0)        . JUMP TO GRAPH                      03002
6S      INI 6  (1)          SLJ    (99)       . INCREASE INDEX  JUMP TO READ       03003
7S      LDA    (LAST)       SUB    (2B)       . LAST = 2                           03004
        AJP 1  (2S1)        STA    (NPTS)     .   NO JUMP TO MOD CHECK             03005
        ENA    (1)          STA    (MOD)      . RESET NPTS AND MOD                 03006
        ENI 6  (1)          LDA    (JTIME)    .   AND INDEX                        03007
        SUB    (TFLAG)      AJP    (L+2)      . MORE TIME                          03010
        AJP 2  (L+1)        SLJ    (9)        .   YES JUMP TO REWIND               03011
8S      SLJ    (1END)       ZRO    (0)        .   NO JUMP TO X-Y POSIT PLOT        03012
9S      ENI 6  (1)          SLJ    (9)        . RESET INDEX  JUMP TO REWIND        03013
10S     ENA    (0)          STA    (NPTS)     . RESET NPTS AND INDEX               03014
        ENI 6  (1)          SLJ    (99)       . JUMP TO READ                       03015
11S     ENA    (2)          ENI    (0)        . NPTS .GT. TWO                      03016
        THS    (NPTS)       SLJ    (9S)       .   NO JUMP TO GRAPH                 03017
        SLJ    (2S)         ZRO    (0)        .   YES JUMP TO GRAPH                03020

* STATE ROUTINE

1ST     EXF    (77521B)     SLJ    (L+4)      . TURN OFF STATE LT                  03021
2ST     ZRO    (0)          ZRO    (0)        . CAP NUMBER                         03022
3ST     ZRO    (0)          ZRO    (0)        . TRACK NUMBER                       03023
4ST     ZRO    (0)          ZRO    (0)        . TYPE OF INTERECPTOR                03024
        LDA    (2ST)        SLJ 4  (1Y)       . DETERMINE CAP TRACK NR             03025
        SIL 2  (3ST)        SLJ 4  (1NUM)     . STROE CAP TRACK NR                 03026
        ALS    (6)          ADD    (R5)       . ASSEMBLE INITIAL MSG               03027
        SCL    (77B)        STA    (E86)      .                                    03030
        ENA    (E84)        SLJ 4  (1MSG)     . SEND INITIAL MSG                   03031
        LDQ 2  (TRACK)      LDL    (MASK4B)   . DETERMINE MAX WPNS                 03032
        ARS    (39)         STA    (4ST)      .                                    03033
        LIL 2  (4ST)        LDQ 2  (IFIG0)    .                                    03034
        LDL    (MASK35)     ARS    (27)       .                                    03035
        STA    (T+9)        ARS    (3)        .                                    03036
        ENQ    (7B)         ADL    (T+9)      .                                    03037
        ARS    (1)          STA    (WPNS)     . DIVIDE MAX WPNS BY 2 AND STORE     03040
        LIL 3  (3ST)        LDQ 3  (KFIG)     .                                    03041
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        LDL    (MASK35)    ARS    (27)      .                                  03042
        STA    (T+9)       ARS    (3)       .                                  03043
        ENQ    (7B)        ADL    (T+9)     .                                  03044
        AJP    (5ST)       ENI    (0)       . AMMO ZERO                        03045
        THS    (WPNS)      SLJ    (6ST)     . AMMO PLUS                        03046
        LDA    (R21)       STA    (E88)     . AMMO MINUS                       03047
        SLJ    (7ST)       ZRO    (0)       .                                  03050
5ST     LDA    (R22)       STA    (E88)     . AMMO ZERO                        03051
        SLJ    (7ST)       ZRO    (0)       .                                  03052
6ST     LDA    (R23)       STA    (E88)     . AMMO PLUS                        03053
7ST     LDA 3  (KFIG)      ARS    (33)      . DETERMINE TIME OF REPORT         03054
        SLJ 4  (1NUM)      ZRO    (0)       .                                  03055
        ADD    (R24)       STA    (E91)     .                                  03056
        LDA    (ITIME)     ENQ    (0)       .                                  03057
        DVI    (60)        ENI 2  (0)       .                                  03060
        THS    (59)        SLJ    (L+2)     . CHECK HOURS                      03061
        SLJ    (L+3)       ZRO    (0)       .                                  03062
        SUB    (60)        INI 2  (100)     .                                  03063
        SLJ    (L-3)       ZRO    (0)       .                                  03064
        ADD    (ZTIME)     INA 2  (0)       .                                  03065
        SLJ 4  (1NUM)      ZRO    (0)       .                                  03066
        ALS    (24)        ADD    (R25)     .                                  03067
        SCL    (77B)       STA    (E94)     .                                  03070
        ENA    (E87)       SLJ 4  (1MSG)    . SEND REPORT                      03071
        LDA    (4ST)       SLJ 4  (1NUM)    . DETERMINE TYPE                   03072
        ADD    (R26)       STA    (E82)     .                                  03073
        ENA    (E82)       SLJ 4  (1MSG)    . SEND TYPE MSG                    03074
        SLJ    (4T)        ZRO    (0)       . RETURN                           03075

* SELECT INTERRUPTS AND INITIALIZING

0T      EXF    (04000B)    EXF    (77105B)  . ALLOW SELECTED INTERRUPTS        03076
        EXF    (77103B)    EXF    (00100B)  . KEYBD1, KEYBD2, AND ARITHMETIC   03077
        ENA    (1A)        SAL    (Z+7B)    . RESET INTERRUPT ADDRESS          03100
        ENA    (400)       STA    (ADD)     . MEMORY ADDRESS DD65 FOR MSG      03101
        ENA    (-377B)     STA    (XP1)     . LEFT SIDE OF PAGE                03102
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 ENA    (377B)       STA    (YP1)      . FIRST LINE OF PRINT                  03103
 ENA    (365B)       STA    (YP2)      . SECOND LINE OF PRINT                 03104
 ENA    (353B)       STA    (YMSG)     . FIRST LINE OF PRINT FOR MSG          03105
 ENA    (44B)        STA    (MM)       . MEMORY INDICATOR                     03106
 ENA    (0)          STA    (IFLAG)    . SET I-FLAG                  =0       03107
 STA    (NEG)        STA    (DFLAG)    . SET NEG AND D-FLAG          =0       03110
 STA    (RAW)        STA    (PFLAG)    . SET RAW AND P-FLAG          =0       03111
 STA    (HSUB)       STA    (HSUR)     . SET HSUB AND HSUR           =0       03112
 STA    (HAC)        STA    (FAC)      . SET HAC AND FAC             =0       03113
 STA    (FSUB)       STA    (FSUR)     . SET FSUB AND FSUR           =0       03114
 STA    (FTIME)      ENA    (1)        . SET SUBTRACT TIME           =0       03115
 STA    (KNR2)       STA    (PRO)      . SET KNR2 AND PRO            =1       03116
 STA    (KNR1)       STA    (KNR)      . SET KNR1 AND KNR            =1       03117
 ENA    (20)         STA    (NPROG)    . NUMBER OF CALLABLE PROGRAMS          03120
 ENA    (6)          STA    (MK)       . NUMBER OF EXECUTIVE ROUTINES         03121
 ENA    (1800)       STA    (MTIME)    . SET MAX TIME FOR GRAPH               03122
 ENA    (0)          STA    (COUNTER)  . DUTY CYCLE CARD                      03123
 LDA    (R27)        STA    (GTIME)    . INITIALIZE GTIME                     03124
 ENI 4 (15)          ENA    (52B)      . SET ALL TRACKS TO NON ACTIVE         03125
 STA 4 (TRACK)       IJP 4 (L)         . LOOP                                 03126
 READ 102, JTITLE                                                             03127
 LDA    (JTITLE)     STA    (TITLE7)   . SET DATE IN GRAPH TITLE              03130
 STA    (TITLE19)    ENI    (0)        .                                      03131
 READ 101,LABLE,XSCALE,YSCALE,IXUP, IYRIGHT,MODEXAX,MODEYAX,IWIDE,            03132
*         IHIGH,IGRID
 READ 101,LABLE,XSCALE1,YSCALE1,IXUP1,IYRT1,MODXAX1,MODYAX1,IWIDE1,           03133
*         IHIGH1,IGRID
 READ 103, SCALE                                                              03134
 READ 104, IP,IPP                                                             03135
 ENA    (1)          STA    (IETT+1)   . INITIALIZE --                        03136
 ENA    (1)          STA    (IEFT+1)   .   EXECUTIVE                          03137
 ENA    (600)        STA    (IEFT+5)   .     TABLES                           03140
 LDA    (IP)         STA    (IEFT+2)   .       .                              03141
 STA    (IETT+2)     STA    (IETT+3)   .         .                            03142
 STA    (IETT+4)     STA    (IETT+6)   .           .                          03143
 INA    (1)          STA    (IEFT+6)   .             .                        03144
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        INA    (1)          STA    (IEFT+4)  .                .                  03145
        INA    (1)          STA    (IEFT+3)  .                 .                 03146
        ENA    (600)        STA    (IETT+5)  .                  .                03147
        ENA    (1)          STA    (PPI)     . SET POINT PLOT INDEX               03150
        LDA    (IPP)        AJP 1  (L+2)     .                                    03151
        ENA    (7G2)        SAL    (7G1)     .                                    03152
        SAU    (7G11)       ENI    (0)       .                                    03153
        LDA    (IEFT+2)     RAD    (IPP)                                          03154

* TIME ROUTINE  EXECUTIVE PROGRAM

        EXF    (02000B)     EXF    (77602B)  . STOP REAL TIME CLOCK AND LT 5A     03155
1T      ENA    (0)          STA    (ITIME)   . RESET JOB TIME CLOCK               03156
2T      ENA    (1)          STA    (NK)      . SET PROGRAM INDEX                  03157
        LDA    (ITIME)      STA    (TIME)    . TIME = REAL TIME                   03160
        AJP    (2K)         RAO    (COUNTER) . IF TIME = 0, JUMP TO 2K            03161
3T      LIL 4  (NK)         LDA    (TIME)    . IF(TIME-IEFT(NK)) IS NEG           03162
        SUB 4  (IEFT)       AJP 3  (4T)      .   JUMP TO 4T                       03163
        LDA 4  (IETT)       ADD    (TIME)    . IEFT(NK)=IETT(NK) + TIME           03164
        STA 4  (IEFT)       LDA    (NK)      . GO TO(1K,1TG,1F,1G,1GR,1INT)NK     03165
        INA    (-1)         AJP    (1K)      . KEYBOARD                           03166
        INA    (-1)         AJP    (1TG)     . TRACK GENERATOR                    03167
        INA    (-1)         AJP    (1F)      . DISPLAY                            03170
        INA    (-1)         AJP    (1G)      . RADAR PROCESSOR                    03171
        INA    (-1)         AJP    (1GR)     . 10 MIN GRAPH ROUTINE               03172
        INA    (-1)         AJP    (1INT)    . INTERCEPT ROUTINE                  03173
4T      LDA    (MK)         SUB    (NK)      . IF(MK-NK).EQ..LT. ZERO             03174
        AJP    (2T)         AJP 3  (2T)      .   JUMP TO 2T                       03175
        RAO    (NK)         SLJ    (3T)      . NK = NK + 1, JUMP TO 3T            03176

* TRANSFER TABLE

0TAB    ZRO    (5)          ZRO    (P0)      . BEGIN                              03177
        ZRO    (6)          ZRO    (P1)      . INTCPT (INTERCEPT)                 03200
        ZRO    (6)          ZRO    (P2)      . LAUNCH                             03201
        ZRO    (7)          ZRO    (P3)      . HISTORY                            03202
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        ZRO    (5)          ZRO    (P4)       . ERROR                          03203
        ZRO    (4)          ZRO    (P5)       . HOLD                           03204
        ZRO    (4)          ZRO    (P6)       . SKIP                           03205
        ZRO    (7)          ZRO    (P7)       . DISPLAY                        03206
        ZRO    (4)          ZRO    (P8)       . DROP                           03207
        ZRO    (8)          ZRO    (P9)       . NOT USED                       03210
        ZRO    (4)          ZRO    (P10)      . STOP                           03211
        ZRO    (5)          ZRO    (P11)      . STEER                          03212
        ZRO    (5)          ZRO    (P12)      . DESIG                          03213
        ZRO    (4)          ZRO    (P13)      . INFO                           03214
        ZRO    (8)          ZRO    (P14)      . NOT USED                       03215
        ZRO    (5)          ZRO    (P15)      . GRAPH                          03216
        ZRO    (7)          ZRO    (P16)      . STATION                        03217
        ZRO    (6)          ZRO    (P17)      . CHANGE                         03220
        ZRO    (5)          ZRO    (P18)      . STATE                          03221
        ZRO    (8)          ZRO    (P19)      . NOT USED                       03222
        ZRO    (8)          ZRO    (P20)      . READY LT                       03223
        ZRO    (4)          ZRO    (P21)      . FADE                           03224
        ZRO    (6)          ZRO    (P22)      . UNFADE                         03225
        ZRO    (5)          ZRO    (P23)      . START                          03226
        ZRO    (5)          ZRO    (P24)      . SCRUB                          03227
        ZRO    (4)          ZRO    (P25)      . PORT                           03230
        ZRO    (4)          ZRO    (P26)      . STBD                           03231
        ZRO    (5)          ZRO    (P27)      . SPEED                          03232
        ZRO    (8)          ZRO    (P28)      . ALTITUDE                       03233
        ZRO    (8)          ZRO    (P29)      . NOT USED                       03234

* TRACK GENERATOR CALLING ROUTINE

1TG     SIU 4 (3TG)         SIL 5 (3TG)       . SAVE INDEXES                   03235
        SLJ 4 (TRAKGEN)     ZRO   (0)         . CALL TRAKGEN                   03236
        ENI 4 (1)           ENI   (0)         .                                03237
2TG     LDQ 4 (IPOSIT)      LDL   (MASKX)     .                                03240
        ARS   (24)          SLJ 4 (FLOAT)     . UNPACK IPOSIT                  03241
        FDV   (SCALE1)      STA 4 (XN)        . UNSCALE X-POSITION             03242
        LDQ 4 (IPOSIT)      ENI   (0)         . STORE IN XN                    03243
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        LDL    (MASKY)      ALS    (24)       . UNSCALE Y-POSITION          03244
        ARS    (24)         SLJ 4  (FLOAT)    . STORE IN YN                 03245
        FDV    (SCALE1)     STA 4  (YN)       .                             03246
        LDQ 4  (JHEAD)      ENI    (0)        . UNPACK JHEAD                03247
        LDL    (MASKY)      ALS    (24)       . UNSCALE Z-POSITION          03250
        ARS    (24)         SLJ 4  (FLOAT)    . STORE IN ZN                 03251
        FDV    (SCALE2)     STA 4  (ZN)       .                             03252
        ISK 4  (15)         SLJ    (2TG)      . LOOP                        03253
        LDA    (TIME)       STA    (KTIME)    .                             03254
        WRITE TAPE MM, XN,YN,ZN,TIME                                        03255

* ADD NOISE ROUTINE HERE OR BEFORE WRITE TAPE

3TG     ENI 4  (N)          ENI 5  (N)        . RESTORE INDEXES             03256
        SLJ    (4T)         ZRO    (0)        . RETURN                      03257

* INFO ROUTINE

1TT     EXF    (77421B)     SLJ    (L+2)      . TURN OFF INFO LT            03260
2TT     ZRO    (0)          ZRO    (0)        . TRACK FOR INFO              03261
        ENA    (2TT)        SLJ 4  (3J0)      . HOOK TRACK                  03262
        ENA    (E73)        SLJ 4  (1MSG)     . OUTPUT TITLE                03263
        LDA    (2TT)        SLJ 4  (1NUM)     .                             03264
        ALS    (36)         SCL    (MASKY)    .                             03265
        STA    (E77)        ENA    (E75)      .                             03266
3TT     SLJ 4  (1MSG)       ZRO    (0)        . OUTPUT TRACK NUMBER         03267
        LDA    (2TT)        ENI    (0)        . CHECK FOR OWN SHIP          03270
        EQS    (OWN)        SLJ    (L+2)      .                             03271
        SLJ    (14TT)       ZRO    (0)        . OWN SHIP JUMP               03272
        LIL 3  (2TT)        LDA 3  (TRACK)    .                             03273
        STA    (2TT)        ENI    (0)        .                             03274
        SSH    (2TT)        SLJ    (9TT)      . JUMP ON HOSTILE             03275
        SSH    (2TT)        SLJ    (5TT)      . JUMP ON NOT SURFACE         03276
        LDA 3  (TRACK)      STA    (2TT)      . SURFACE TRACK               03277
        LDA    (R12)        STA    (E79)      .                             03300
        LDQ    (2TT)        QRS    (24)       .                             03301
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        LDL    (777B)      SLJ 4 (1NUM)     .                                03302
        SAL    (3TT)       LDQ   (3TT)      .                                03303
        LDL    (77B)       ADD   (R18)      .                                03304
        STA    (E80)       ENA   (0)        .                                03305
        STA    (E81)       ENA   (E78)      .                                03306
        SLJ 4  (1MSG)      ZRO   (0)        .                                03307
4TT     LDA 3  (CRS)       SLJ 4 (FIX)      . SURFACE INFO                   03310
        SLJ 4  (1NUM)      ZRO   (0)        .                                03311
        ALS    (6)         ADD   (R7)       .                                03312
        STA    (E79)       LDA 3 (SPD)      .                                03313
        SLJ 4  (FIX)       ZRO   (0)        .                                03314
        SLJ 4  (1NUM)      ZRO   (0)        .                                03315
        LRS    (6)         ADD   (MASK17)   .                                03316
        ADD    (R8)        STA   (E80)      .                                03317
        ENA    (0)         LLS   (6)        .                                03320
        ALS    (42)        ADD   (R15)      .                                03321
        STA    (E81)       ENA   (0)        .                                03322
        STA    (E82)       ENA   (E78)      .                                03323
        SLJ    (12TT)      ZRO   (0)        . OUTPUT SURFACE INFO            03324
5TT     SSH    (2TT)       SLJ   (7TT)      . JUMP ON NO A/C                 03325
        LDA 3  (TRACK)     STA   (2TT)      . A/C TRACK                      03326
        LDQ    (2TT)       QRS   (24)       .                                03327
        LDL    (777B)      SLJ 4 (1NUM)     .                                03330
        ADD    (R5)        STA   (E79)      .                                03331
        ENA    (0)         STA   (E80)      .                                03332
        ENA    (E78)       SLJ 4 (1MSG)     .                                03333
6TT     LDA 3  (CRS)       SLJ 4 (FIX)      . A/C INFO                       03334
        SLJ 4  (1NUM)      ZRO   (0)        .                                03335
        ALS    (6)         ADD   (R7)       .                                03336
        STA    (E79)       LDA 3 (SPD)      .                                03337
        SLJ 4  (FIX)       ZRO   (0)        .                                03340
        SLJ 4  (1NUM)      ZRO   (0)        .                                03341
        LRS    (6)         ADD   (MASK17)   .                                03342
        ADD    (R8)        STA   (E80)      .                                03343
        ENA    (0)         LLS   (6)        .                                03344
        ALS    (42)        ADD   (R9)       .                                03345
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        STA    (E81)       LDA 3 (ZN)      .                                  03346
        SLJ 4  (FIX)       ZRO   (0)       .                                  03347
        SLJ 4  (1NUM)      ZRO   (0)       .                                  03350
        ALS    (12)        ADD   (5300B)   .                                  03351
        SCL    (77B)       STA   (E82)     .                                  03352
        ENA    (0)         STA   (E83)     .                                  03353
        ENA    (E78)       SLJ   (12TT)    . OUTPUT A/C INFO                  03354
7TT     SSH    (2TT)       SLJ   (13TT)    . JUMP IF NON DESIGNATED TRACK     03355
        LDA 3  (TRACK)     STA   (2TT)     . SUBMARINE TRACK                  03356
        LDQ    (2TT)       QRS   (24)      .                                  03357
        LDL    (777B)      SLJ 4 (1NUM)    .                                  03360
        SCL    (MASK10)    ADD   (R13)     .                                  03361
        STA    (E80)       LDA   (R12)     .                                  03362
        STA    (E79)       ENA   (0)       .                                  03363
        STA    (E81)       ENA   (E78)     .                                  03364
        SLJ 4  (1MSG)      ZRO   (0)       .                                  03365
8TT     LDA 3  (CRS)       SLJ 4 (FIX)     . SUBMARINE INFO                   03366
        SLJ 4  (1NUM)      ZRO   (0)       .                                  03367
        ALS    (6)         ADD   (R7)      .                                  03370
        STA    (E79)       LDA 3 (SPD)     .                                  03371
        SLJ 4  (FIX)       ZRO   (0)       .                                  03372
        SLJ 4  (1NUM)      ZRO   (0)       .                                  03373
        LRS    (6)         ADD   (MASK17)  .                                  03374
        ADD    (R8)        STA   (E80)     .                                  03375
        ENA    (0)         LLS   (6)       .                                  03376
        ALS    (42)        ADD   (R14)     .                                  03377
        STA    (E81)       LAC 3 (ZN)      .                                  03400
        SLJ 4  (FIX)       ZRO   (0)       .                                  03401
        SLJ 4  (1NUM)      ZRO   (0)       .                                  03402
        ALS    (24)        ADD   (R10)     .                                  03403
        SCL    (77B)       STA   (E82)     .                                  03404
        ENA    (0)         STA   (E83)     .                                  03405
        ENA    (E78)       SLJ   (12TT)    . OUTPUT SUBMARINE INFO            03406
9TT     SSH    (2TT)       SLJ   (10TT)    . JUMP ON NOT SURFACE              03407
        LDA 3  (TRACK)     STA   (2TT)     . HOSTILE SURFACE TRACK            03410
        LIU 5  (2TT)       LDA 5 (F11)     .                                  03411
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        SUB    (20B)        ADD    (E78)      .                                  03412
        ADD    (R16)        STA    (E79)      .                                  03413
        ENA    (0)          STA    (E80)      .                                  03414
        ENA    (E78)        SLJ 4  (1MSG)     .                                  03415
        SLJ    (4TT)        ZRO    (0)        . JUMP TO SURFACE INFO              03416
10TT    SSH    (2TT)        SLJ    (11TT)     . JUMP ON NOT A/C                   03417
        LDA 3  (TRACK)      STA    (2TT)      . HOSTILE A/C TRACK                 03420
        LDQ    (2TT)        QRS    (24)       .                                  03421
        LDL    (777B)       SLJ 4  (1NUM)     .                                  03422
        ALS    (36)         SCL    (77B)      .                                  03423
        STA    (E80)        LDA    (R11)      .                                  03424
        STA    (E79)        ENA    (0)        .                                  03425
        STA    (E81)        ENA    (E78)      .                                  03426
        SLJ 4  (1MSG)       ZRO    (0)        .                                  03427
        SLJ    (6TT)        ZRO    (0)        . JUMP TP A/C INFO                  03430
11TT    SSH    (2TT)        SLJ    (13TT)     . JUMP ON NON DESIGNATED TRACK      03431
        LDA 3  (TRACK)      STA    (2TT)      . HOSTILE SUBMARINE TRACK           03432
        LIU 5  (2TT)        LDA 5  (F11)      .                                  03433
        SUB    (20B)        ADD    (E78)      .                                  03434
        ADD    (R17)        STA    (E79)      .                                  03435
        ENA    (0)          STA    (E80)      .                                  03436
        ENA    (E78)        SLJ 4  (1MSG)     .                                  03437
        SLJ    (8TT)        ZRO    (0)        . JUMP TO SUBMARINE INFO            03440
12TT    SLJ 4  (1MSG)       ZRO    (0)        . OUTPUT ALL MSG ROUTINE            03441
        LDA 3  (ZN)         STA    (ZTAR)     .                                  03442
        LDA 3  (XN)         STA    (XTAR)     .                                  03443
        LDA 3  (YN)         STA    (YTAR)     .                                  03444
        LIL 3  (OWN)        LAC 3  (XN)       .                                  03445
        FAD    (XTAR)       STA    (XTAR)     .                                  03446
        LAC 3  (YN)         FAD    (YTAR)     .                                  03447
        STA    (YTAR)       ENA    (XTAR)     .                                  03450
        SAL    (COURSE+1)   ENA    (YTAR)     .                                  03451
        SAL    (COURSE+2)   ENA    (DTAR)     .                                  03452
        SAL    (COURSE+3)   ENA    (S6C)      .                                  03453
        SAL    (COURSE+5)   ENA    (RTAR)     .                                  03454
        SAL    (COURSE+6)   SLJ 4  (COURSE)   . JUMP TO COURSE                    03455
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        LDA    (DTAR)      AJP    (4T)       . RETURN OWN SHIP          03456
        LDA    (E96)       STA    (E79)      . FORM RANGE MSG           03457
        LDA    (ZTAR)      AJP    (L+2)      .                          03460
        AJP 2  (L+6)       ENI    (0)        .                          03461
        LDA    (RTAR)      FMU    (2000.)    .                          03462
        SLJ 4  (FIX)       ZRO    (0)        .                          03463
        SLJ 4  (1NUM)      ZRO    (0)        .                          03464
        STA    (E80)       LDA    (E105)     .                          03465
        SLJ    (L+4)       ZRO    (0)        .                          03466
        LDA    (RTAR)      SLJ 4  (FIX)      .                          03467
        SLJ 4  (1NUM)      ZRO    (0)        .                          03470
        STA    (E80)       LDA    (E97)      .                          03471
        STA    (E81)       ENA    (E78)      .                          03472
        SLJ 4  (1MSG)      ZRO    (0)        . OUTPUT RANGE MSG         03473
        LDA    (E98)       STA    (E79)      .                          03474
        LDA    (DTAR)      SLJ 4  (FIX)      .                          03475
        SLJ 4  (1NUM)      ZRO    (0)        .                          03476
        STA    (E80)       LDA    (E99)      .                          03477
        STA    (E81)       ENA    (0)        .                          03500
        STA    (E82)       ENA    (E78)      .                          03501
        SLJ 4  (1MSG)      ZRO    (0)        . OUTPUT BEARING MESSAGE   03502
        LDA    (OWN)       AJP 1  (L+6)      . JUMP IF OWN SHIP REFERENCE 03503
        LDA    (E102)      STA    (E79)      .                          03504
        LDA    (E103)      STA    (E80)      .                          03505
        LDA    (E104)      STA    (E81)      .                          03506
        ENA    (E78)       SLJ 4  (1MSG)     . OUTPUT REFERENCE MESSAGE 03507
        SLJ    (4T)        ZRO    (0)        . RETURN                   03510
        LDA    (E100)      STA    (E79)      .                          03511
        LDA    (E101)      STA    (E80)      .                          03512
        SLJ    (L-4)       ZRO    (0)        .                          03513
13TT    LDA    (R19)       STA    (E79)      . UNIDENTIFIED TRACK       03514
        LDA    (R20)       STA    (E80)      .                          03515
        ENA    (0)         STA    (E81)      .                          03516
        ENA    (E78)       SLJ 4  (1MSG)     .                          03517
        LDA 3  (ZN)        AJP    (4TT)      . JUMP ACCORDING TO ALTITUDE 03520
        AJP 2  (6TT)       AJP 3  (8TT)      .                          03521
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14TT  ENA   (E95)       STA   (E79)     .                                  03522
      ENA   (0)         STA   (E80)     .                                  03523
      SLJ 4 (1MSG)      ZRO   (0)       . OUTPUT OWN SHIP INFO             03524
      SLJ   (4TT)       ZRO   (0)       . JUMP TO SURFACE INFO             03525

* STEER COMMAND ROUTINE

1U    EXF   (77405B)    SLJ   (L+2)     . TURN OFF STEER LT                03526
2U    ZRO   (0)         ZRO   (0)       . CAP NUMBER                       03527
      LDA   (2U)        SLJ 4 (1Y)      . DETERMINE CAP TRACK NR           03530
      LDA   (MASK22)    RAD 2 (TRACK)   . SET STEER BIT                    03531
      SLJ   (4T)        ZRO   (0)       . RETURN                           03532

* STATION COMMAND ROUTINE

1V    EXF   (77505B)    SLJ   (L+4)     . TURN OFF STATION LT              03533
2V    ZRO   (0)         ZRO   (0)       . CAP NUMBER                       03534
3V    ZRO   (0)         ZRO   (0)       . RANGE FROM CARRIER               03535
4V    ZRO   (0)         ZRO   (0)       . BEARING DEGREES TRUE             03536
      ENA   (2V)        SLJ 4 (1ZZ)     . DETERMINE CAP TRACK NR           03537
      LDA   (MASK20)    RAD 2 (TRACK)   . SET STATION BIT                  03540
      SLJ   (4T)        ZRO   (0)       . RETURN                           03541

* SKIP INTERCEPT COMMAND ROUTINE

1W    EXF   (77205B)    SLJ   (L+2)     . TURN OFF INTCPT LT               03542
2W    ZRO   (0)         ZRO   (0)       . CAP TO SKIP                      03543
      LDA   (2W)        SLJ 4 (1Y)      . DETERMINE CAP TRACK NR           03544
      LDQ   (MASK19)    LDL 2 (TRACK)   . IS CAP MAKING AN INTERCEPT       03545
      AJP   (3W)        LDA   (MASK21)  .   NO JUP -- YES SET SKIP BIT     03546
      RAD 2 (TRACK)     SLJ   (4T)      . RETURN                           03547
3W    LDA   (2W)        SLJ 4 (1NUM)    . SEND MSG                         03550
      STA   (T+1)       LDA   (R5)      .   CAP  XX NOT                    03551
      RAD   (T+1)       STA   (E63)     .     MAKING                       03552
      ENA   (E63)       SLJ 4 (1MSG)    .       INTERECPT                  03553
      SLJ   (4T)        ZRO   (0)       . RETURN                           03554
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* LAUNCH COMMAND ROUTINE

1X    EXF    (77211B)    SLJ    (L+5)      . TURN OFF LAUNCH LT                03555
2X    ZRO    (0)         ZRO    (0)        . CAP NUMBER                        03556
3X    ZRO    (0)         ZRO    (0)        . RANGE                             03557
4X    ZRO    (0)         ZRO    (0)        . BEARING DEGREES TRUE              03560
5X    ZRO    (0)         ZRO    (0)        . TYPE OF INTERCEPTOR               03561
      ENI 2  (16)        LDQ    (MASK11)   .                                   03562
      ENA    (52B)       ENI    (0)        .                                   03563
      MEQ 2  (TRACK)     SLJ    (5Q)       . SEARCH FOR NON ACTIVE TRACK       03564
      LDA    (MASK9L)    STA 2  (TRACK)    . SET CAP BITS                      03565
      LDA    (MASK20)    RAD 2  (TRACK)    .                                   03566
      ENA    (2X)        SLJ 4  (1X1)      . GET CAP NUMBER                    03567
      LDA    (2X)        ALS    (24)       .                                   03570
      RAD 2  (TRACK)     ENI    (0)        . SET CAP NUMBER                    03571
      ENA    (2X)        SLJ 4  (1ZZ)      . DETERMINE STATION INFO            03572
      LDA    (5X)        AJP    (7X)       . JUMP IF NO TYPE GIVEN             03573
      INA    (-1)        AJP    (7X)       . INITIALIZE                        03574
      INA    (1)         ENI    (0)        .   INTERCEPTOR TYPE                03575
      ALS    (39)        RAD 2  (TRACK)    .     FUEL                          03576
      LIL 5  (5X)        LDA 5  (IFIG0)    .       AND                         03577
6X    STA 2  (KFIG)      LDA    (ITIME)    .         LAUNCH TIME               03600
      RAD 2  (KFIG)      SLJ    (4T)       .                                   03601
7X    LDA    (MASK4B)    RAD 2  (TRACK)    . MAKE INTECPTOR F4                 03602
      LDA    (IFIG7)     SLJ    (6X)       .                                   03603

* DETERMINE FRIENDLY A/C NUMBER ROUTINE

1X1   SLJ    (N)         STA    (T+8)      . EXIT/ENTRY                        03604
      LDA 7  (T+8)       ENI    (0)        . CHECK TO SEE IF NUMBER .GT.       03605
      THS    (FAC)       SLJ    (L+3)      .   FAC  YES JUMP  NO USE FAC       03606
      RAO    (FAC)       STA 7  (T+8)      .                                   03607
      SLJ    (1X1)       ZRO    (0)        . RETURN                            03610
      STA    (FAC)       SLJ    (1X1)      . SET NEW FAC   RETURN              03611
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* FIND CAP NUMBER ROUTINE

1Y    SLJ    (N)          STA    (2Y)       . EXIT/ENTRY                          03612
      ENI 2  (1)          ENI    (0)        .                                     03613
      SSK 2  (TRACK)      SLJ    (L+7)      . CHECK FOR FRIENDLY                  03614
      LDQ 2  (TRACK)      LDA    (MASK16)   . CHECK FOR A/C BIT                   03615
      MEQ    (MASK16)     SLJ    (L+5)      .                                     03616
      LDQ 2  (TRACK)      QRS    (24)       .                                     03617
      LDL    (77B)        ENI    (0)        .                                     03620
      EQS    (2Y)         SLJ    (L+2)      . CHECK FOR CAP NUMBER                03621
      SLJ    (1Y)         ZRO    (0)        . RETURN WITH TRACK NUMBER IN B2      03622
      ISK 2  (15)         SLJ    (L-7)      . LOOP                                03623
      LDA    (2Y)         SLJ 4  (1NUM)     . ERROR EXIT                          03624
      ALS    (6)          STA    (T+1)      . CAP  XX NOT AIRBORNE                03625
      LDA    (R5)         RAD    (T+1)      .   MSG TO BE SENT                    03626
      STA    (E60)        ENA    (E60)      .                                     03627
      SLJ 4  (1MSG)       ZRO    (0)        .                                     03630
      SLJ    (4T)         ZRO    (0)        . RETURN                              03631
2Y    ZRO    (0)          ZRO    (0)        . CAP NUMBER                          03632

* PROGRAM ARGUMENT AND ADDRESS TABLE

0Z    ZRO    (0)          ZRO    (1Z)       . BEGIN                               03633
      ZRO    (1)          ZRO    (1Q)       . INTCPT (INTERCEPT)                  03634
      ZRO    (4)          ZRO    (1X)       . LAUNCH                              03635
      ZRO    (2)          ZRO    (1L)       . HISTORY                             03636
      ZRO    (0)          ZRO    (4T)       . ERROR                               03637
      ZRO    (0)          ZRO    (1PQ)      . HOLD/PAUSE                          03640
      ZRO    (1)          ZRO    (1W)       . SKIP                                03641
      ZRO    (0)          ZRO    (1D)       . DISPLAY                             03642
      ZRO    (0)          ZRO    (1R)       . DROP                                03643
      ZRO    (0)          ZRO    (2P)       . NOT USED                            03644
      ZRO    (0)          ZRO    (1S)       . STOP                                03645
      ZRO    (1)          ZRO    (1U)       . STEER                               03646
      ZRO    (2)          ZRO    (1J)       . DESIG                               03647
      ZRO    (0)          ZRO    (1TT)      . INFO                                03650
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        ZRO    (0)          ZRO    (2P)       . NOT USED                          03651
        ZRO    (0)          ZRO    (3GR)      . GRAPH                             03652
        ZRO    (3)          ZRO    (1V)       . STATION                           03653
        ZRO    (7)          ZRO    (1C)       . CHANGE                            03654
        ZRO    (1)          ZRO    (1ST)      . STATE                             03655
        ZRO    (0)          ZRO    (2P)       . NOT USED                          03656
        ZRO    (0)          ZRO    (4T)       . READY                             03657
0Z10    ZRO    (0)          ZRO    (11C)      . FADE                              03660
        ZRO    (0)          ZRO    (11C)      . UNFADE                            03661
        ZRO    (0)          ZRO    (10C)      . START                             03662
        ZRO    (0)          ZRO    (11C)      . SCRUB                             03663
        ZRO    (0)          ZRO    (13C)      . PORT                              03664
        ZRO    (0)          ZRO    (13C)      . STBD                              03665
        ZRO    (0)          ZRO    (12C)      . SPEED                             03666
        ZRO    (0)          ZRO    (15C)      . ALTITUDE                          03667
        ZRO    (0)          ZRO    (2P)       . NOT USED                          03670

* BEGIN ROUTINE

1Z      EXF    (77203B)     EXF    (77603B)   . TURN OFF BEGIN AND READY LTS      03671
        ENA    (1)          STA    (IFLAG)    . SET IFLAG                         03672
        LDA    (CLK)        STA    (Z)        . RESET CLOCK                       03673
        EXF    (1000B)      SLJ 4  (TRAKGEN)  . INITIAL CALL OF TRAKGEN           03674
        AJP 3  (2Z)         ENI    (0)        . NTRACKS GREATER THAN 16 JUMP      03675
        STA    (T+11)       LIL 4  (T+11)     .                                   03676
        LDA 4  (OB0)        ALS    (36)       .                                   03677
        STA    (R)          LDA    (E9)       .                                   03700
        RAD    (R)          LDA    (E10)      .   INITIAL                         03701
        STA    (R+1)        LDA    (E11)      .     MESSAGE                       03702
        STA    (R+2)        LDA    (E12)      .                                   03703
        STA    (R+3)        ENA    (R)        .                                   03704
        SAL    (2E)         SAU    (6E)       .                                   03705
        ENI 5  (1)          SLJ    (2E)       .                                   03706
2Z      ENA    (XP1)        SAL    (PRINT+1)  . ERRO MSG -- NTRACKS .GT. OR       03707
        ENA    (YP2)        SAL    (PRINT+2)  .   .EQ. 16  CHECK DATA DECK        03710
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        ENA   (1)          SAL   (PRINT+3)  .      TRY AGAIN                  03711
        ENA   (E50)        ENQ   (0B)       .                                 03712
        SLJ 4 (PRINT)      ZRO   (0)        .                                 03713
        SLS   (0T)         ZRO   (0)        . RESTART                         03714

* CAP NUMBER AND STATION INFORMATION ROUTINE

1ZZ     SLJ   (N)          SLJ   (L+4)      . EXIT/ENTRY                      03715
2ZZ     ZRO   (0)          ZRO   (0)        . CAP NUMBER                      03716
3ZZ     ZRO   (0)          ZRO   (0)        . RANGE FROM CARRIER              03717
4ZZ     ZRO   (0)          ZRO   (0)        . BEARING DEGREES TRUE            03720
        STA   (T+1)        LDA 7 (T+1)      . TRANSFER                        03721
        STA   (2ZZ)        RAO   (T+1)      .   ARGUMENTS                     03722
        LDA 7 (T+1)        STA   (3ZZ)      .     TO THIS ROUTINE             03723
        RAO   (T+1)        LDA 7 (T+1)      .                                 03724
        STA   (4ZZ)        LDA   (2ZZ)      . GET CAP TRACK NR                03725
        SLJ 4 (1Y)         ZRO   (0)        .                                 03726
        SIL 2 (2ZZ)        LDA   (2ZZ)      .                                 03727
        ALS   (42)         SLJ 4 (6Q)       . DETERMINE TRACK1 WORD           03730
        LIL 3 (8Q)         STA   (T+2)      .                                 03731
        LDA 3 (TRACK1)     SCL   (MASK36)   .                                 03732
        ADD   (T+2)        STA 3 (TRACK1)   . SET UP TRACK1 WORD              03733
        LDA   (3ZZ)        AJP   (5ZZ)      . STATION GIVEN  NO JUMP TO       03734
        SLJ 4 (FLOAT)      ZRO   (0)        .   HOOK STATION                  03735
        STA   (3ZZ)        ENI   (0)        . FLOAT                           03736
        LDA   (4ZZ)        SLJ 4 (FLOAT)    .   ARGUMENTS                     03737
        STA   (4ZZ)        LDA   (AXIS)     . CONVERT TO RADIANS              03740
        FSB   (4ZZ)        FMU   (RADIANS)  .                                 03741
        STA   (4ZZ)        ENA   (4ZZ)      .                                 03742
        SAL   (COSF+1)     SAL   (SINF+1)   .                                 03743
        SLJ 4 (COSF)       ZRO   (0)        . DETERMINE X AND Y               03744
        FMU   (3ZZ)        SLJ 4 (FIX)      .   POSITION                      03745
        SCL   (-777B)      ALS   (27)       .     OF                          03746
        RAD 3 (TRACK1)     SLJ 4 (SINF)     .       STATION                   03747
        FMU   (3ZZ)        SLJ 4 (FIX)      .                                 03750
        SCL   (-777B)      ALS   (18)       . SET TRACK1 WORD                 03751
```

```
        RAD 3 (TRACK1)    SLJ   (1ZZ)     . RETURN                    03752
5ZZ     LDA   (EIGHT)     FDV   (RHO)      . DETERMINE                 03753
        STA   (INC)       FAD   (XPIP)     .   X AND Y                 03754
        STA   (XDESIG)    LDA   (INC)      .     POSITION              03755
        FAD   (YPIP)      SLJ 4 (FIX)      .      OF                   03756
        SCL   (-777B)     ALS   (25)       .                           03757
        RAD 3 (TRACK1)    LDA   (XPIP)     .                           03760
        SLJ 4 (FIX)       ZRO   (0)        .                           03761
        SCL   (-777B)     ALS   (34)       .                           03762
        RAD 3 (TRACK1)    SLJ   (1ZZ)      .                           03763

        END
```

APPENDIX II-A

1. Identification.

Title: TRAKGEN

Category: Track Generator

Programmer: A. C. Casciato

Organization: U. S. Naval Postgraduate School

Date: April 1965

2. Purpose.

This subroutine is designed to generate fine grain, three dimensional position information in order to simulate radar or sonar track information. The subroutine generates up to 15 tracks simultaneously.

3. Program Sections.

3.1 lRET - Subroutine Entry, Initial Call. This section checks for the initial call and initializes all arrays and flags, reads in the initial position data for preprogrammed tracks, and sets all tracks to standby.

3.2 lTRAK - Process Maneuver Table Entries. This section reads in maneuver command data from the Data Process Section, the Keyboard Command Section, and the Maneuver Table and updates the maneuver code in the track matrix. It selects the proper maneuver section for track processing.

3.3 lWAIT - Utility Section. This section contains several small sections used by other portions of the subroutine.

3.4 lMOVE - Update Tracks. This section unpacks the track matrix information and routes the data through the proper maneuver routines

in the necessary order. After processing, the data is repacked into the track matrix.

3.5 1EXIT - Exit From Subroutine. This section restores the index information and returns control to the calling program.

3.6 1GO - Constant Course Section. This section increments X and Y position information when the track is not in a turn.

3.7 1TURN - Turn Section. This section processes the X and Y position information when the track is in a turn.

3.8 IDIVE - Climb Section. This section increments the altitude information when the track is climbing/diving.

3.9 1SPD - Speed Change Section. This section increments the speed information when the track is changing speed.

3.10 1CT - Multiple Maneuver Section. This section sets the proper flags to route the track information through the necessary maneuver sections when performing more than one maneuver.

3.11 1KEY - Keyboard Command Section. This section processes keyboard command information into a form similar to that of a maneuver table data card.

3.12 7KEY - Data Process Command Section. This section converts tactical data command information into the form of keyboard command information.

4. Limitations on Subroutine Quantities.

4.1 The maximum and minimum values for subroutine TRACKGEN input quantities are:

X and Y position:	± 279 miles.
Altitude	± 98,689 feet.
Course:	0 to 360 degrees.
Speed:	0 to 4095 knots.
Turn Rate:	0.1 to 25.5 degrees per second.
Climb Rate:	43* to 65,535 feet per minute.
Acceleration:	1 to 255 knots per second.

* The climb rate has a minimum of 43 feet per minute with a calling period of one second. With the six second calling period, a minimum climb rate of eight feet per minute is possible.

5. Rules Governing Track Commands.

5.1 The first command for a preprogrammed track must be a "Start Track" command.

5.2 More than one command may be given to the same track at the same time.

5.3 Normal maneuver commands may be given to a track even if it has been faded.

5.4 Once a track has been maneuvered by the keyboard console or by the data process section, further preprogrammed commands are ignored. This does not apply to the keyboard "Fade" or "Unfade" commands.

5.5 A track which has been scrubbed by any means cannot be restarted from the preprogrammed data deck.

5.6 Any maneuver may be continued to a new assigned limit by inserting a maneuver command with the new limit. The previous maneuver does not have to be completed before ordering the new limit.

APPENDIX II-B

SUBROUTINE TRAKGEN FLOW DIAGRAMS

Subroutine Entry and Exit

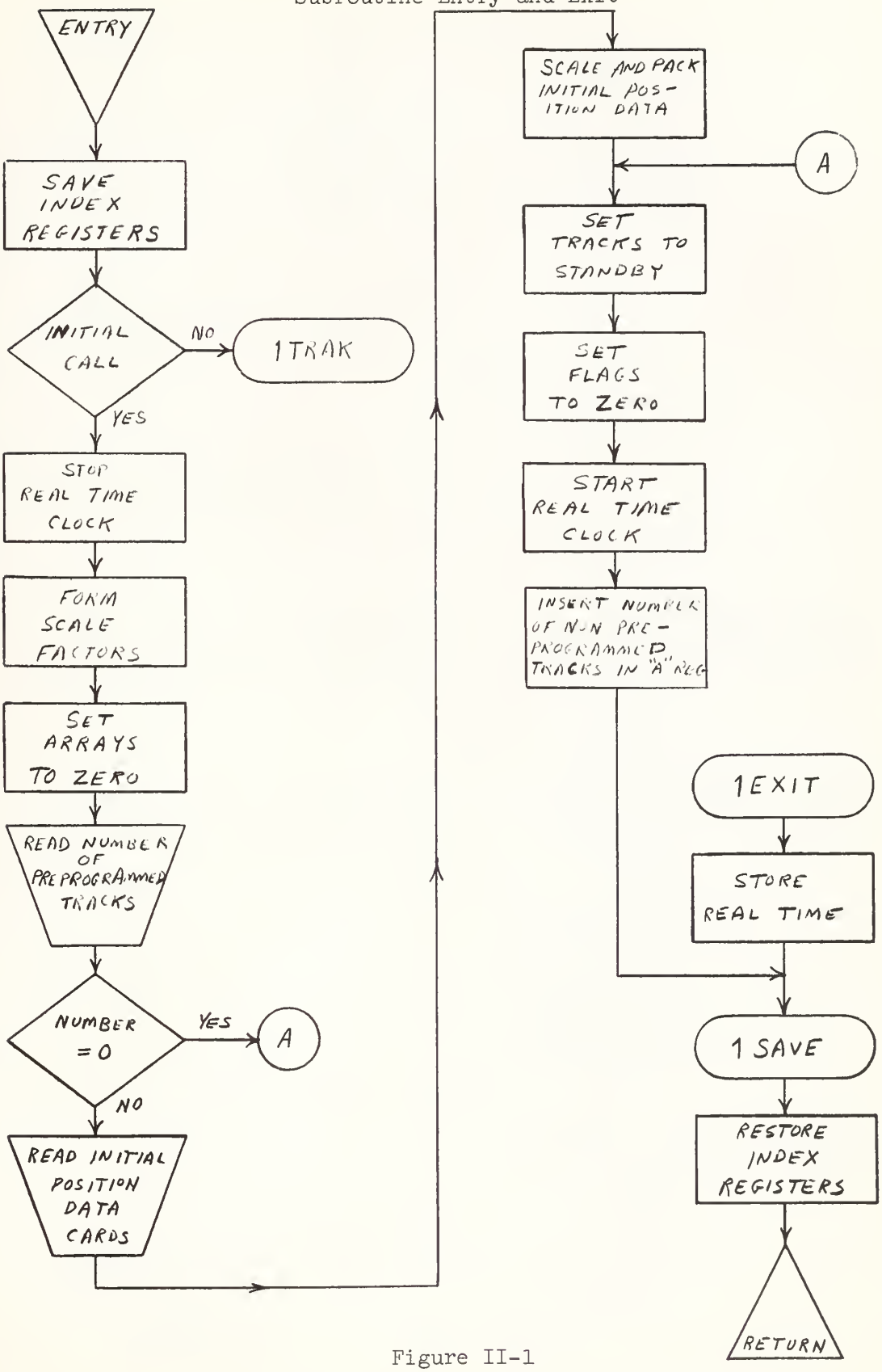


Figure II-1

Update Maneuver Codes

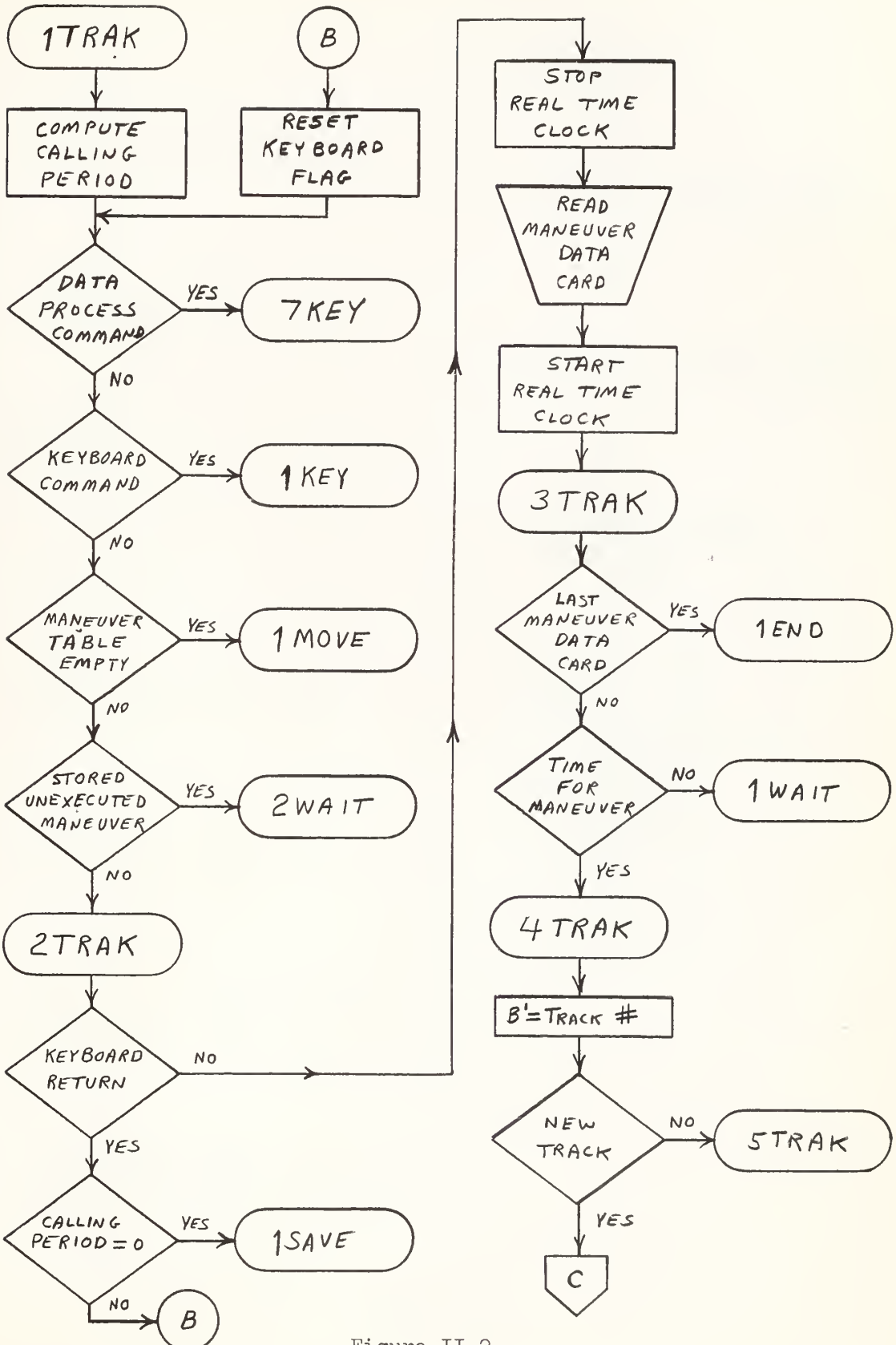


Figure II-2

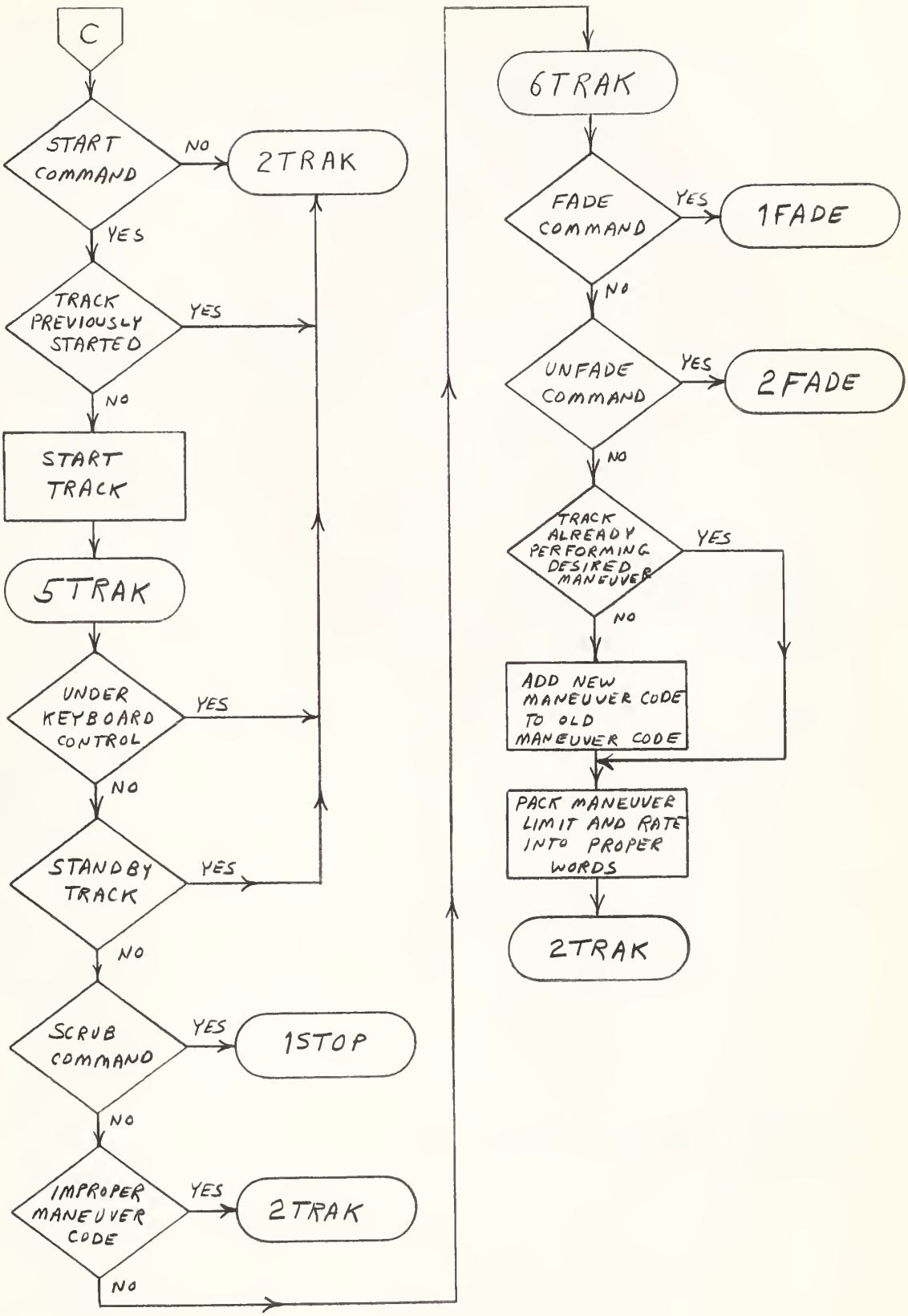

C
START COMMAND
NO
2TRAK
YES
TRACK PREVIOUSLY STARTED
YES
NO
START TRACK
5TRAK
UNDER KEYBOARD CONTROL
YES
NO
STANDBY TRACK
YES
NO
SCRUB COMMAND
YES
1STOP
NO
IMPROPER MANEUVER CODE
YES
2TRAK
NO
6TRAK
FADE COMMAND
YES
1FADE
NO
UNFADE COMMAND
YES
2FADE
NO
TRACK ALREADY PERFORMING DESIRED MANEUVER
YES
NO
ADD NEW MANEUVER CODE TO OLD MANEUVER CODE
PACK MANEUVER LIMIT AND RATE INTO PROPER WORDS
2TRAK

Figure II-3

Update Track Positions

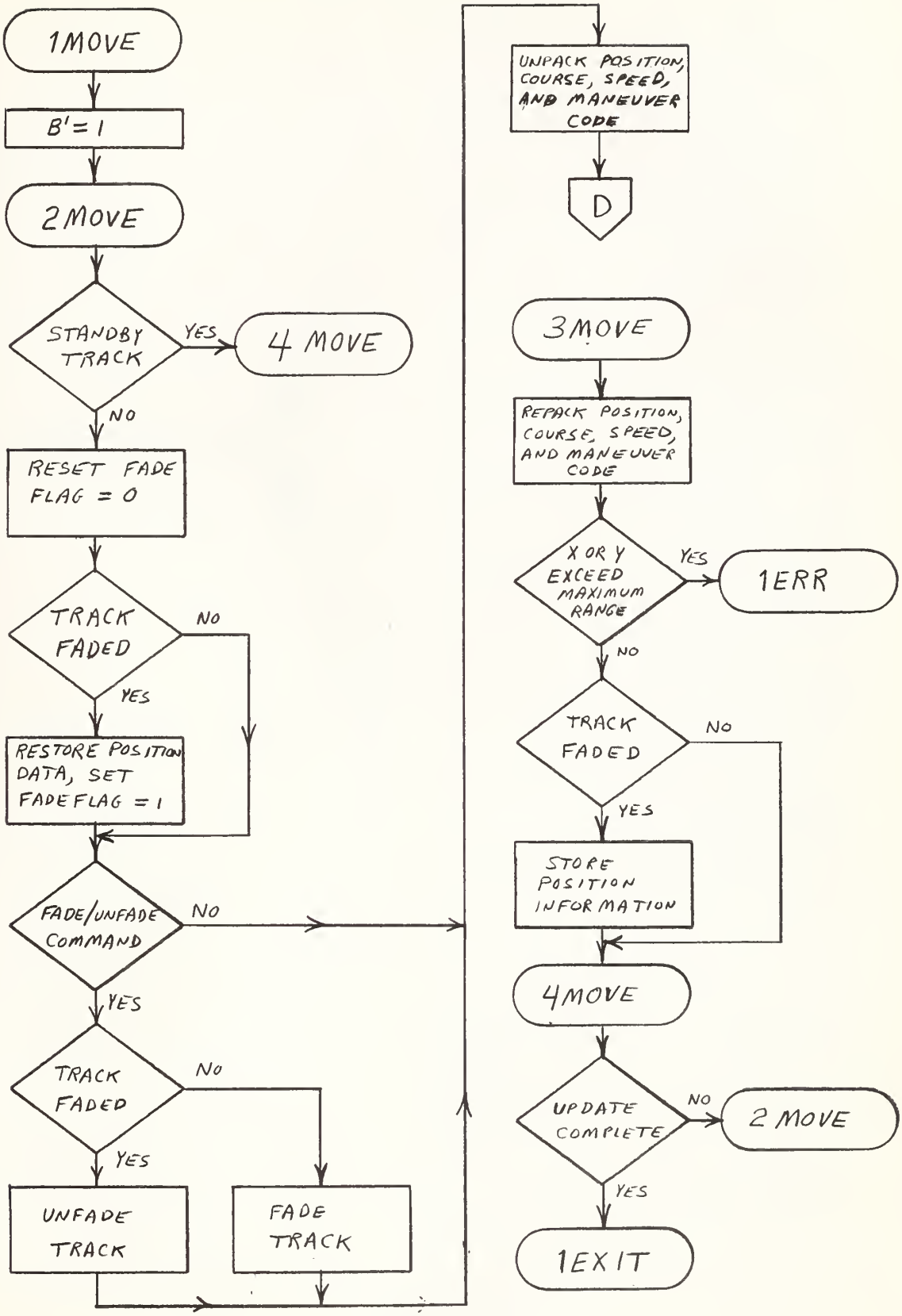
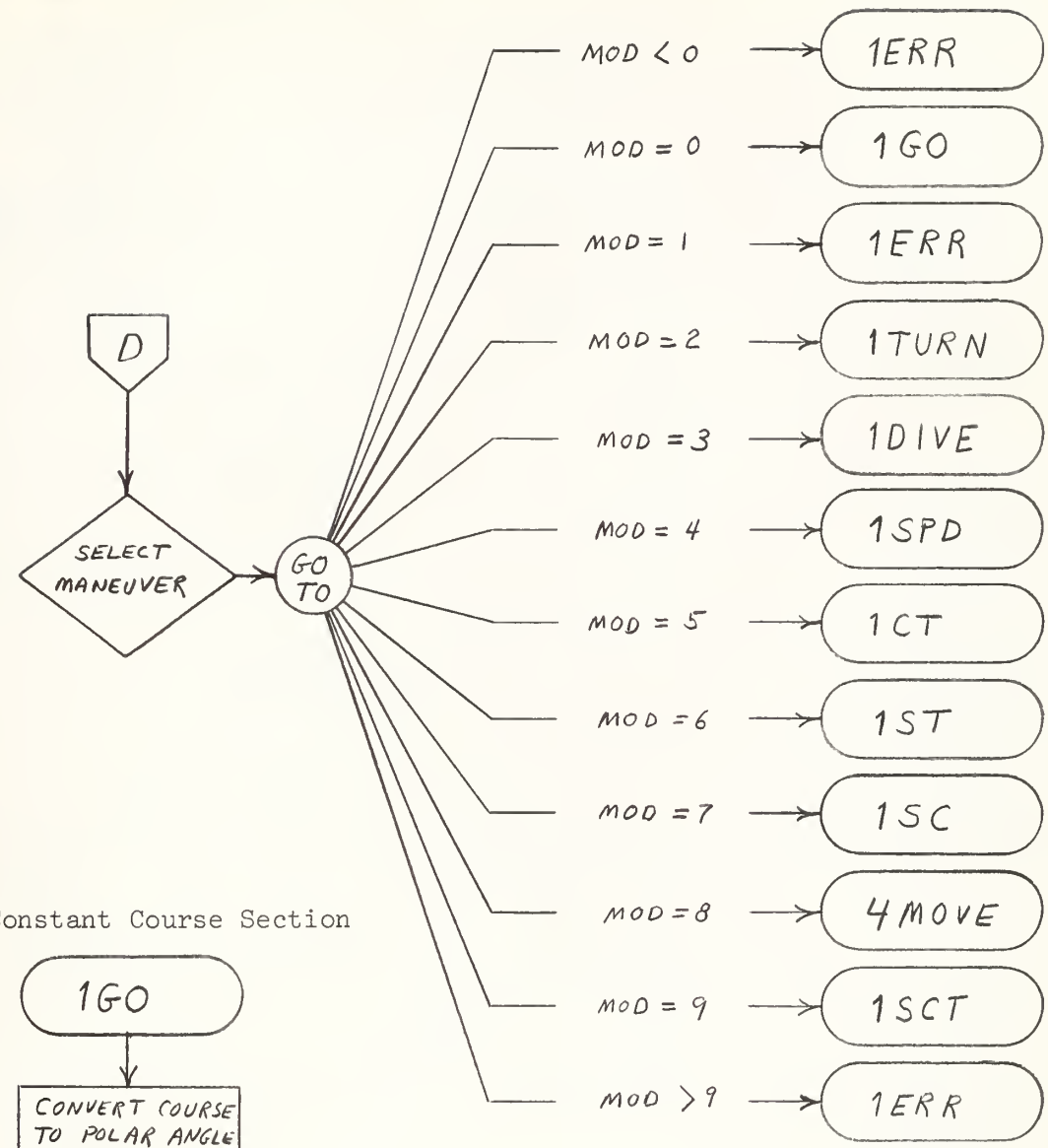
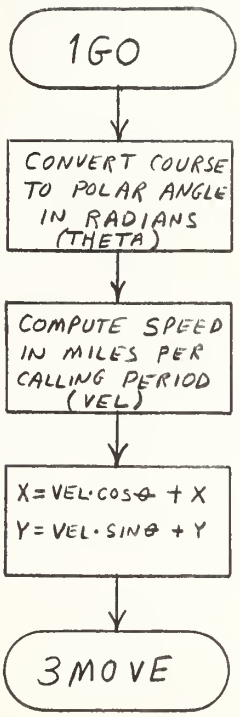


Figure II-4

Select Maneuver



Constant Course Section


1GO
CONVERT COURSE TO POLAR ANGLE IN RADIANS (THETA)
COMPUTE SPEED IN MILES PER CALLING PERIOD (VEL)
X = VEL · COS θ + X
Y = VEL · SIN θ + Y
3MOVE

Utility Section

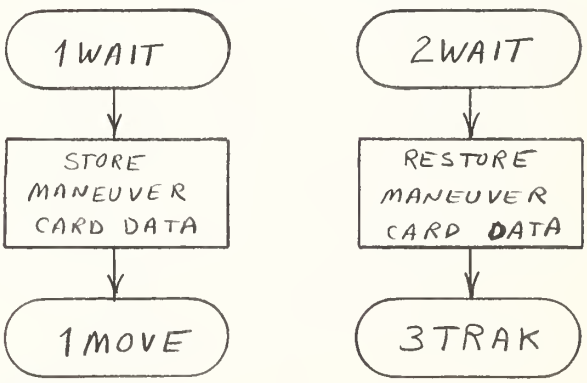


Figure II-5

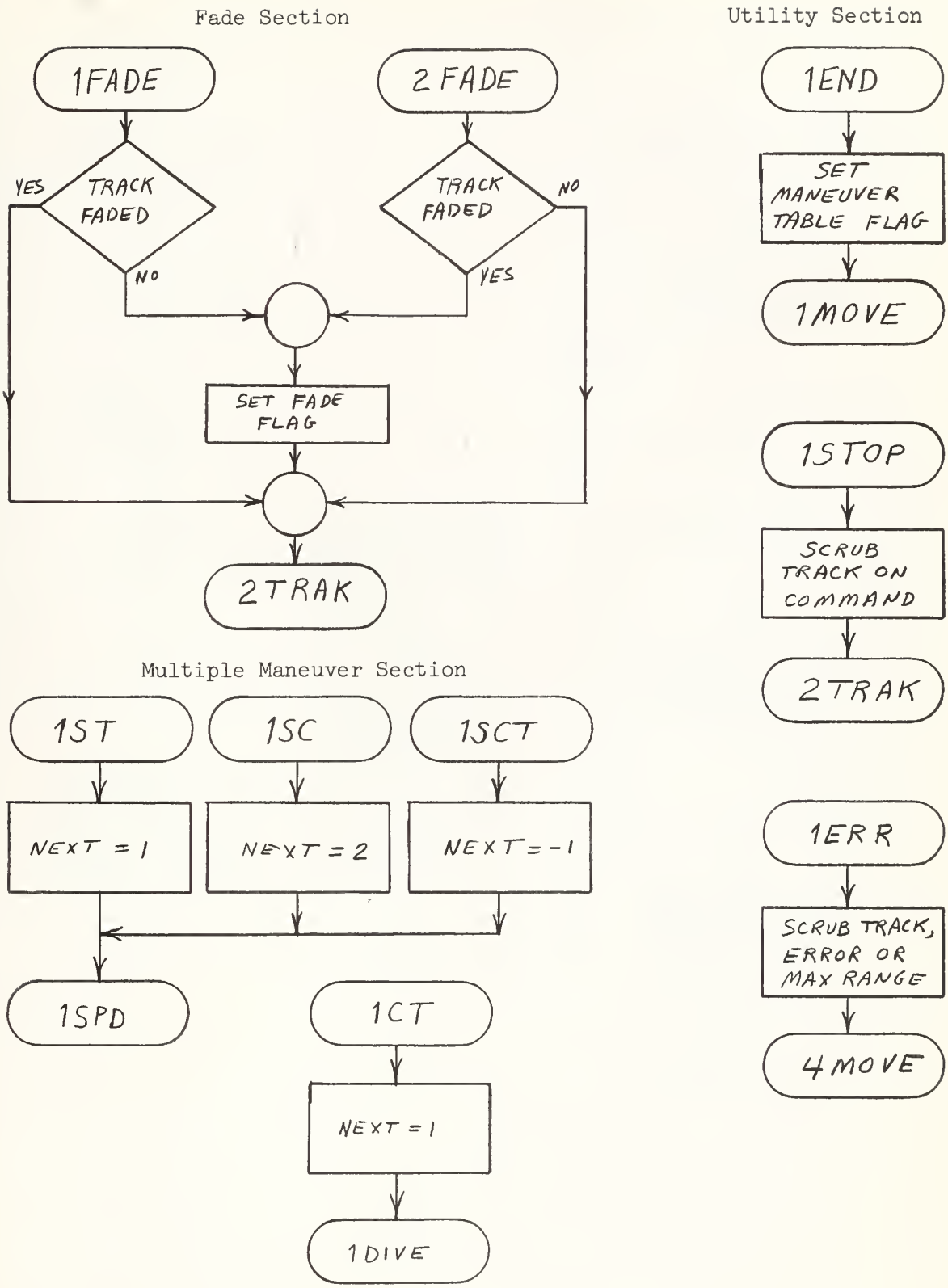

Fade Section
1FADE
2 FADE
YES
TRACK FADED
NO
TRACK FADED
NO
YES
SET FADE FLAG
2TRAK
Utility Section
1END
SET MANEUVER TABLE FLAG
1MOVE
1STOP
SCRUB TRACK ON COMMAND
2TRAK
1ERR
SCRUB TRACK, ERROR OR MAX RANGE
4MOVE
Multiple Maneuver Section
1ST
1SC
1SCT
NEXT = 1
NEXT = 2
NEXT = -1
1SPD
1CT
NEXT = 1
1DIVE

Figure II-6

Turn Section

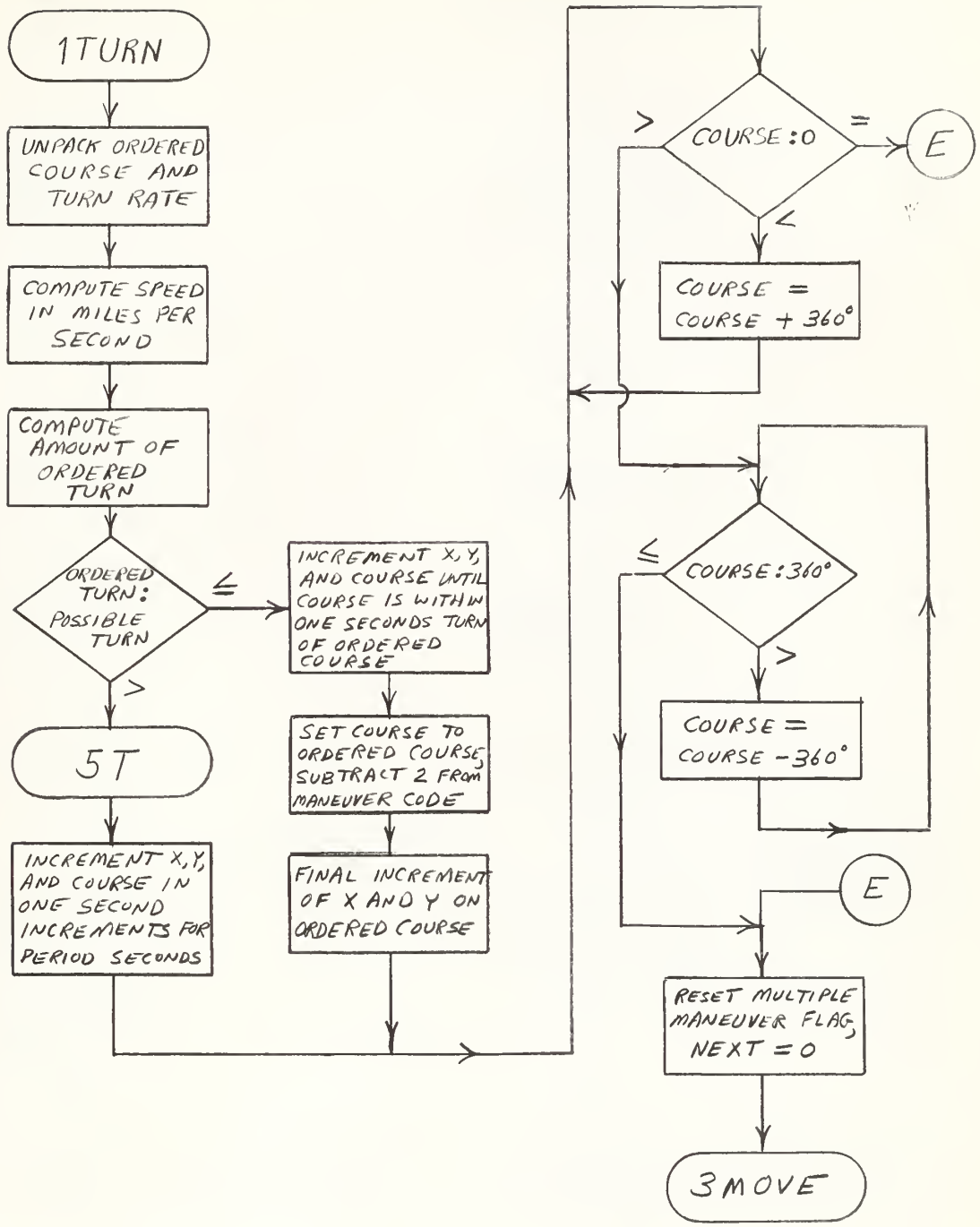

1TURN
UNPACK ORDERED COURSE AND TURN RATE
COMPUTE SPEED IN MILES PER SECOND
COMPUTE AMOUNT OF ORDERED TURN
ORDERED TURN: POSSIBLE TURN
≤
>
INCREMENT X, Y, AND COURSE UNTIL COURSE IS WITHIN ONE SECONDS TURN OF ORDERED COURSE
SET COURSE TO ORDERED COURSE, SUBTRACT 2 FROM MANEUVER CODE
FINAL INCREMENT OF X AND Y ON ORDERED COURSE
5T
INCREMENT X, Y, AND COURSE IN ONE SECOND INCREMENTS FOR PERIOD SECONDS
COURSE:0
>
=
<
E
COURSE = COURSE + 360°
≤
COURSE:360°
>
COURSE = COURSE -360°
E
RESET MULTIPLE MANEUVER FLAG, NEXT = 0
3MOVE

Figure II-7

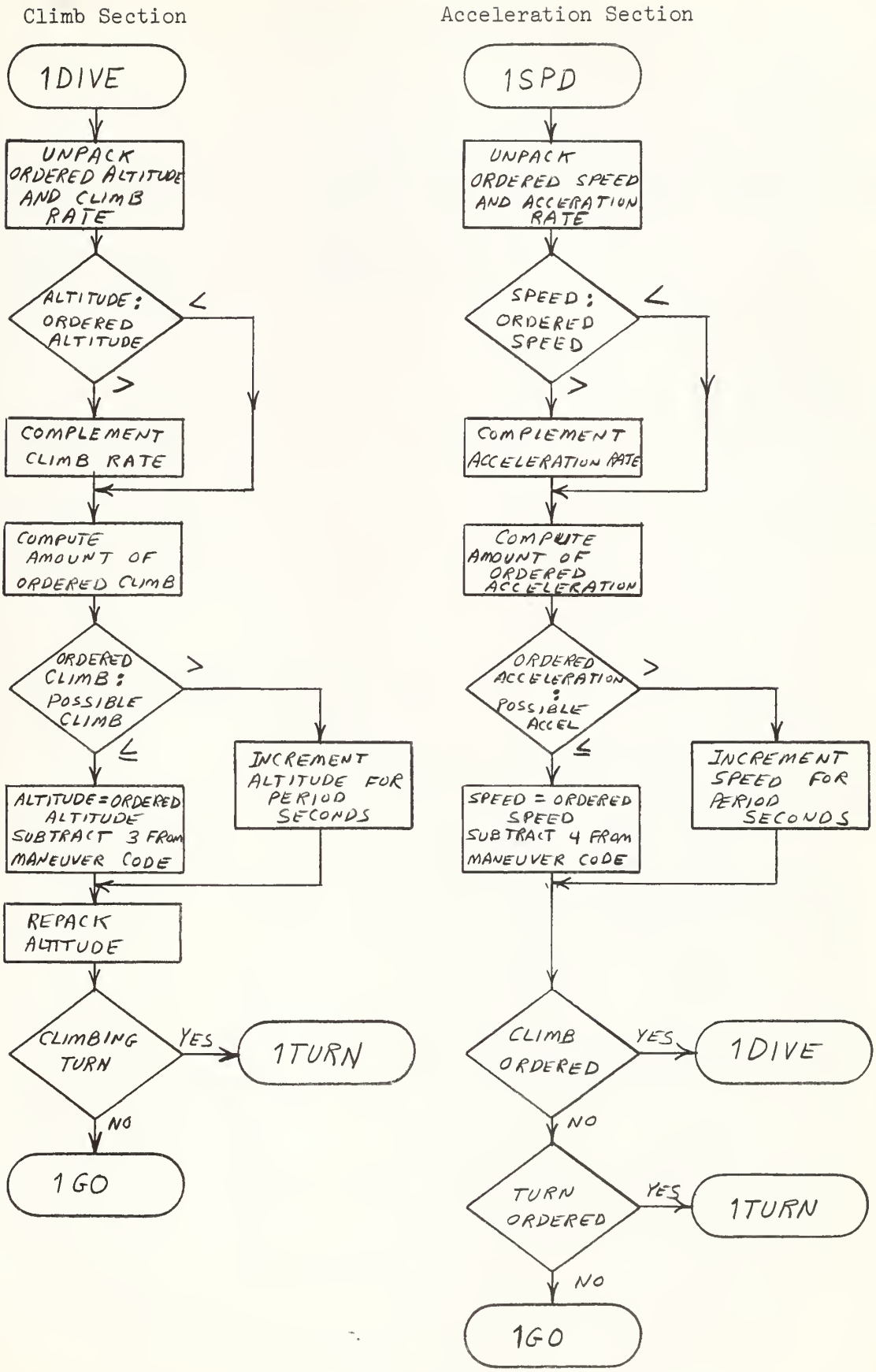

Climb Section
1DIVE
UNPACK ORDERED ALTITUDE AND CLIMB RATE
ALTITUDE : ORDERED ALTITUDE
<
>
COMPLEMENT CLIMB RATE
COMPUTE AMOUNT OF ORDERED CLIMB
ORDERED CLIMB : POSSIBLE CLIMB
>
≤
INCREMENT ALTITUDE FOR PERIOD SECONDS
ALTITUDE = ORDERED ALTITUDE SUBTRACT 3 FROM MANEUVER CODE
REPACK ALTITUDE
CLIMBING TURN
YES
1TURN
NO
1GO
Acceleration Section
1SPD
UNPACK ORDERED SPEED AND ACCERATION RATE
SPEED : ORDERED SPEED
<
>
COMPLEMENT ACCELERATION RATE
COMPUTE AMOUNT OF ORDERED ACCELERATION
ORDERED ACCELERATION : POSSIBLE ACCEL
>
≤
INCREMENT SPEED FOR PERIOD SECONDS
SPEED = ORDERED SPEED SUBTRACT 4 FROM MANEUVER CODE
CLIMB ORDERED
YES
1DIVE
NO
TURN ORDERED
YES
1TURN
NO
1GO

Figure II-8

Keyboard Command Section

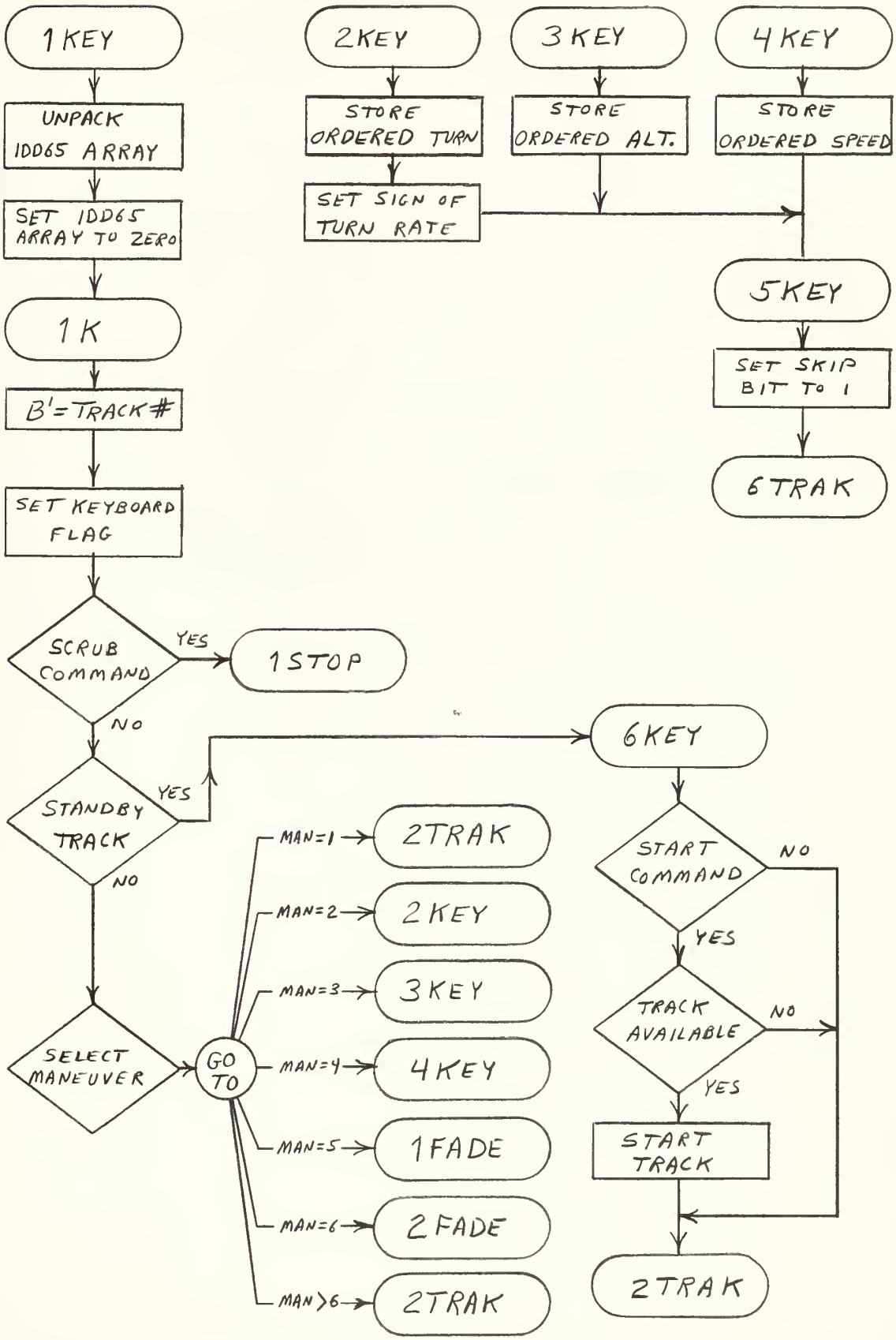


Figure II-9

Data Process Command Section

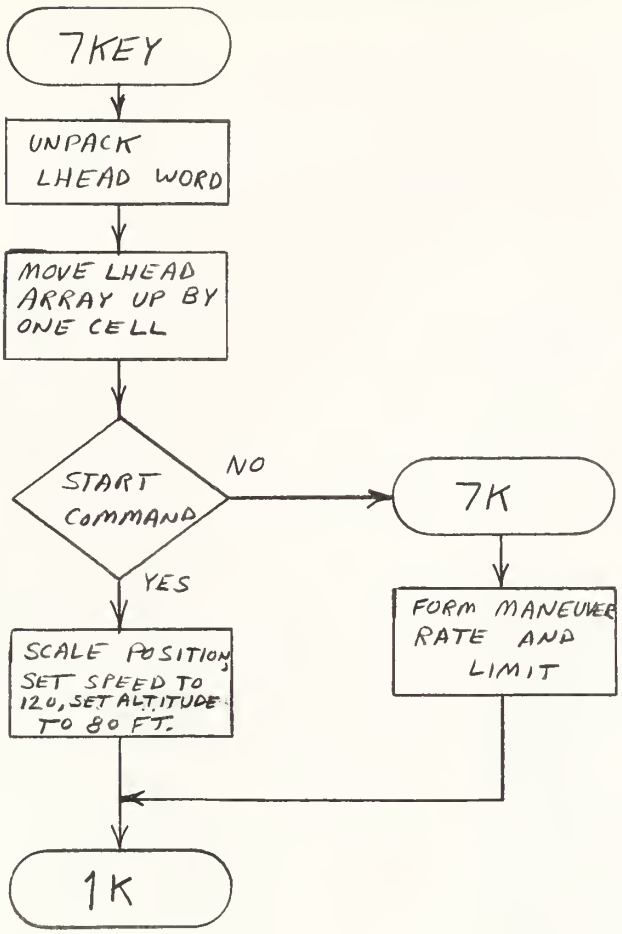


Figure II-10

```
      MACHINE TRAKGEN

*  DATA CARDS - EACH ENTRY MUST BE RIGHT JUSTIFIED IN SPECIFIED COLUMNS
*       1. NUMBER OF PREPROGRAMMED TRACKS, 15 MAXIMUM, COLUMNS 1-2
*       2. INITIAL POSITION CARDS, ONE FOR EACH PREPROGRAMMED TRACK IN
*          ORDER OF INCREASING TRACK NUMBER WITH THE LAST ONE BEING 15
*             A. X POSITION IN MILES, +- 279 MILES MAXIMUM, COLUMNS 1-10
*             B. Y POSITION IN MILES, +- 279 MILES MAXIMUM, COLUMNS 11-20
*                NOTE - X AND Y POSITIONS MAY HAVE UP TO 4 DECIMAL PLACES
*             C. ALTITUDE IN FEET, +- 98689 FEET MAXIMUM, COLUMNS 25-30
*             D. COURSE IN DEGREES, COLUMNS 38-40
*             E. SPEED IN KNOTS, 4095 KNOTS MAXIMUM, COLUMNS 47-50
*       3. MANEUVER CARDS, ONE FOR EACH MANEUVER
*             A. TIME FOR MANEUVER IN SECONDS, COLUMNS 1-10
*             B. TRACK NUMBER, COLUMNS 19-20
*             C. MANEUVER CODE, COLUMN 30
*                   1  START TRACK
*                   2  TURN
*                   3  CLIMB/DIVE
*                   4  CHANGE SPEED
*                   5  FADE TRACK
*                   6  UNFADE TRACK
*                   8  SCRUB TRACK
*             D. ORDERED COURSE IN DEGREES, ORDERED SPEED IN KNOTS, OR
*                ORDERED ALTITUDE IN FEET, COLUMNS 35-40
*             E. MANEUVER RATE, COLUMNS 43-50, THIS ENTRY MAY HAVE ONE.
*                DECIMAL PLACE FOR TURN RATE
*                   POSITIVE TURN RATE SIGNIFIES A STARBOARD TURN,
*                   NEGATIVE TURN RATE SIGNIFIES A PORT TURN
*                INSERT TURN RATE IN DEGREES PER SECOND, 25.5 MAXIMUM,
*                INSERT CLIMB RATE IN FEET PER MINUTE, 65535 MAXIMUM, 43
*                MINIMUM, INSERT ACCELERATION RATE IN KNOTS PER SECOND,
*                255 MAXIMUM.
*          LAST MANEUVER CARD MUST HAVE MANEUVER TIME EQUAL TO ZERO
```

```
*              TRAKGEN VARIABLES AND CONSTANTS
*
*       AXIS          CONVERSION FACTOR - DEGREES TO RADIANS
*       CRS           TRACK COURSE
*       DEGREES       360 DEGREES SCALED BY TEN
*       DPS           TURN RATE, TENTHS OF DEGREES PER SECOND
*       FFLAG         FADE/UNFADE COMMAND BIT
*       IALT          ORDERED ALTITUDE
*       ICHECK        ABSOLUTE VALUE OF TURN RATE
*       ICRS          TRACK COURSE
*       IDD65         KEYBOARD COMMAND ARRAY
*       IDPS          TURN RATE, TENTHS OF DEGREES PER SECOND
*       IFADE         FADE BIT, 1 - TRACK FADED
*       IFPS          CLIMB RATE, FEET PER SECOND
*       IHEAD         COURSE, SPEED, AND MANEUVER CODE ARRAY
*       IKPS          ACCELERATION RATE, KNOTS PER SECOND
*       IPERIOD       TIME BETWEEN SUBROUTINE CALLS
*       IPOSIT        X AND Y POSITION ARRAY
*       IPOSIT1       INITIAL X AND Y POSITION ARRAY, FADE ARRAY
*       IRATE         SCRATCH WORK CELL FOR MANEUVER RATE
*       ISCALE1       SCALE FACTOR FOR X AND Y POSITION
*       ISCALE2       SCALE FACTOR FOR ALTITUDE
*       ISKIP         KEYBOARD CONTROLLED BIT, 1 - KEYBOARD CONTROLLED
*       ISPD          TRACK SPEED
*       ITER          NUMBER OF ITERATIONS IN TURN ROUTINE
*       IVEL          ORDERED SPEED
*       IX            TRACK X POSITION
*       IY            TRACK Y POSITION
*       IZ            TRACK ALTITUDE
*       JCHECK        ICHECK * IPERIOD
*       JCRS          ORDERED COURSE IN DEGREES
*       JFPS          ABSOLUTE VALUE OF CLIMB RATE
*       JHEAD         ALTITUDE ARRAY
*       JHEAD1        INITIAL ALTITUDE ARRAY, FADE ARRAY
*       JUMP          SCRATCH WORK CELL FOR AMOUNT OF MANEUVER
*       KCRS          ORDERED COURSE IN TENTHS OF DEGREES
```

```
*          KEY          KEYBOARD RETURN FLAG
*          KHEAD        ORDERED SPEED ARRAY
*          KMAN         KEYBOARD MANEUVER CODE
*          KPS          ABSOLUTE VALUE OF ACCELERATION RATE
*          LAST         MANEUVER TABLE FLAG,   1 - MANEUVER TABLE EMPTY
*          LEFT         STORE MANEUVER DATA FLAG
*          LHEAD        DATA PROCESS COMMAND ARRAY
*          LIMIT        DESIRED MANEUVER LIMIT
*          LIMITH       MANEUVER LIMIT FOR DELAYED MANEUVER
*          LTIME        TIME OF LAST SUBROUTINE CALL IN SECONDS
*          MAN          MANEUVER CODE
*          MANH         MANEUVER CODE FOR DELAYED MANEUVER
*          MAX          MAXIMUM X OR Y RANGE BEFORE OVERFLOW
*          MOD          MANEUVER CODE
*          MODPOS       CURRENT TRACK MANEUVER CODE, LEFT JUSTIFIED
*          MOD8         MANEUVER CODE FOR STANDBY TRACK
*          MTIME        EXECUTION TIME FOR MANEUVER
*          MTIMEH       DELAYED EXECUTION TIME FOR MANEUVER
*          NACTIVE      NUMBER OF NON PREPROGRAMMED TRACKS
*          NEXT         MULTIPLE MANEUVER FLAG
*          NORTH        360 DEGREES SCALED BY TEN
*          NR           TRACK NUMBER
*          NRH          TRACK NUMBER FOR DELAYED MANEUVER
*          NTIME        TIME OF PRESENT SUBROUTINE CALL IN SECONDS
*          NTRACKS      NUMBER OF PREPROGRAMMED TRACKS
*          PERIOD       TIME BETWEEN SUBROUTINE CALLS
*          RATE         MANEUVER RATE
*          RATEH        MANEUVER RATE FOR DELAYED MANEUVER
*          SCALE1       SCALE FACTOR FOR X AND Y POSITION
*          SCALE2       SCALE FACTOR FOR ALTITUDE
*          SPD          TRACK SPEED
*          TEMP         SCRATCH WORK CELL
*          THETA        COURSE POLAR ANGLE IN RADIANS
*          VEL          TRACK SPEED IN MILES/SECOND OR MILES/PERIOD
*          X            TRACK X POSITION
*          Y            TRACK Y POSITION
```

```
      RSV(IPOSIT=15,IPOSIT1=15,IHEAD=15,JHEAD=15,JHEAD1=15,KHEAD=15,
     *    LHEAD=60,IDD65=10)
      COMMON IPOSIT,IHEAD,JHEAD,LHEAD,IDD65,ISCALE1,ISCALE2,SCALE1,
     *       SCALE2,NTIME
      LIB(FLOATFIX = FLOAT, FIXFLOAT = FIX, COSF, SINF, XABSF, SIGNF)

 1000 FORMAT(I2)                                                        00000
 1001 FORMAT(2F10.0,4X,I6,7X,I3,6X,I4)                                  00001
 1002 FORMAT(I10,8X,I2,9X,I1,4X,I6,2X,F8.0)                             00002

      CON(MASK1  = 7777777700000000B, MASK2  = 75777777777777B,
     *    MASK3  = 7777777777770000B, MASK4  = 03777777777777B,
     *    MASK5  = 7777777777777000B, MASK6  = 74000000000000B,
     *    MASK7  = 7777777777777760B, MASK8  = 00377777000000B,
     *    MASK9  = 7777777777777400B, MASK10 = 77777777000777B,
     *    MASK11 = 00000000777777B, MASK12 = 77777000777777B,
     *    MASK13 = 77400777777777B, MASK14 = 74000000777777B,
     *    MASK15 = 74377777000000B, MASK16 = 77777777776000B,
     *    MASK17 = 77777760000777B, MASK18 = 77770017777777B,
     *    MASK19 = 00000017777770000B, MASK20 = 00007760000777B)
      CON(MT1 = 4400000000000000B, MT2 = 3000000000000000B,
     *    MT3 = 2400000000000000B, MT4 = 1000000000000000B,
     *    MC1 = 4400000000000000B, MC2 = 3400000000000000B,
     *    MC3 = 2400000000000000B, MC4 = 1400000000000000B,
     *    MS1 = 4400000000000000B, MS2 = 3400000000000000B,
     *    MS3 = 3000000000000000B, MS4 = 2000000000000000B)
      CON(IZERO  = 0, IONE   = 1, ITWO   = 2, ITHREE = 3, IFOUR  = 4,
     *    IFIVE  = 5, ISIX   = 6, ISEVEN = 7, IEIGHT = 8, ININE  = 9,
     *    ITEN  = 10, I15   = 15)
      CON(ISKIP = 0200000000000000B, MOD8 = 4000000000000000B, I85 = 85,
     *    I30000 = 30000, AXIS = 4500., RADIANS = .0017453293,
     *    DEGREES = 3600., MAX = 37777777B, IFADE = 0100000000000000B,
     *    FFLAG = 0040000000000000B, SIXTY = 60., NORTH = 3600,
     *    TEN = 10.)
```

```
* ENTRY TO SUBROUTINE

1RET  SLJ    (*)          ENI    (0)        . RETURN JUMP
      SIU 1  (1SAVE)      SIL 2  (1SAVE)    . SAVE
      SIU 3  (2SAVE)      SIL 4  (2SAVE)    .   INDEX
      SIU 5  (3SAVE)      SIL 6  (3SAVE)    .     REGISTERS
      LDA    (NTIME)      AJP 1  (1TRAK)    . JUMP IF NOT INITIAL CALL
      EXF    (2000B)      ENI    (0)        . STOP REAL TIME CLOCK
      LDA    (I30000)     STA    (ISCALE1)  . FORM ISCALE1
      LDA    (I85)        STA    (ISCALE2)  . FORM ISCALE2
      LDA    (ISCALE1)    SLJ 4  (FLOAT)    .
      STA    (SCALE1)     ENI    (0)        . FORM SCALE1
      LDA    (ISCALE2)    SLJ 4  (FLOAT)    .
      STA    (SCALE2)     ENI 1  (1)        . FORM SCALE2
      ENA    (0)          ENI    (0)        . SET IPOSIT, IHEAD,
      STA 1  (IPOSIT)     STA 1  (IHEAD)    .     JHEAD, AND KHEAD
      STA 1  (JHEAD)      STA 1  (KHEAD)    .         ARRAYS TO ZERO
      ISK 1  (15)         SLJ    (L-2)      .
      ENI 1  (1)          ENA    (0)        . SET LHEAD
      STA 1  (LHEAD)      ENI    (0)        .   ARRAY TO
      ISK 1  (60)         SLJ    (L-1)      .     ZERO
      ENI 1  (1)          ENA    (0)        . SET IDD65
      STA 1  (IDD65)      ENI    (0)        .   ARRAY TO
      ISK 1  (10)         SLJ    (L-1)      .     ZERO

* READ, SCALE, AND PACK INITIAL POSITION DATA

      READ 1000, NTRACKS
      LDA    (NTRACKS)    AJP    (2EXIT)    . JUMP IF NO PREPROGRAM TRACKS
      SAU    (2READ)      ENI 1  (1)        .
1READ SIL 1  (TEMP)       LDA    (TEMP)     . FORM
      ADD    (I15)        SUB    (NTRACKS)  .   ARRAY
      STA    (TEMP)       LIL 2  (TEMP)     .     SUBSCRIPT
      READ 1001, X,Y,IZ,ICRS,ISPD
      LDA    (X)          FMU    (SCALE1)   .
      SLJ 4  (FIX)        ZRO    (0)        .
```

```
      SCL    (MASK1)      ALS    (24)       .                                  00037
      STA 2  (IPOSIT1)    LDA    (Y)        . PACK INITIAL X POSITION          00040
      FMU    (SCALE1)     SLJ 4  (FIX)      .                                  00041
      SCL    (MASK1)      RAD 2  (IPOSIT1)  . PACK INITIAL Y POSITION          00042
      LDA    (IZ)         MUI    (ISCALE2)  .                                  00043
      STA 2  (JHEAD1)     LDA    (ICRS)     . PACK INITIAL ALTITUDE            00044
      MUI    (ITEN)       ALS    (12)       .                                  00045
      STA 2  (IHEAD)      LDA    (ISPD)     . PACK INITIAL COURSE              00046
      SCL    (MASK3)      RAD 2  (IHEAD)    . PACK INITIAL SPEED               00047
2READ ISK 1  (*)          SLJ    (1READ)    .                                  00050

* SET UNUSED TRACKS TO STANDBY, SET FLAGS TO ZERO

2EXIT ENA    (15)         SUB    (NTRACKS)  .                                  00051
      STA    (NACTIVE)    ENI 1  (1)        .                                  00052
      LDA 1  (IHEAD)      SST    (MOD8)     . SET TRACKS                       00053
      STA 1  (IHEAD)      ENI    (0)        .   TO STANDBY                     00054
      ISK 1  (15)         SLJ    (L-2)      .                                  00055
      ENA    (0)          STA    (LTIME)    . SET FLAGS                        00056
      STA    (LAST)       STA    (LEFT)     .   TO ZERO                        00057
      STA    (NEXT)       EXF    (1000B)    . START REAL TIME CLOCK            00060
      LDA    (NACTIVE)    SLJ    (1SAVE)    . END OF INITIAL CALL              00061

* NON INITIAL CALL, PROCESS MANEUVER TABLE ENTRIES

1TRAK LDA    (NTIME)      SUB    (LTIME)    . COMPUTE CALLING PERIOD           00062
      STA    (IPERIOD)    SLJ 4  (FLOAT)    . STORE IPERIOD                    00063
      STA    (PERIOD)     ENI    (0)        . STORE PERIOD                     00064
      LDA    (LHEAD+1)    AJP 3  (7KEY)     . JUMP IF DATA PROCESS COMMAND     00065
      LDA    (IDD65+9)    AJP 1  (1KEY)     . JUMP IF KEYBOARD COMMAND         00066
      LDA    (LAST)       AJP 1  (1MOVE)    . JUMP IF MANEUVER TABLE EMPTY     00067
      LDA    (LEFT)       AJP 1  (2WAIT)    . JUMP IF HOLDING A MANEUVER       00070
2TRAK LDA    (KEY)        AJP    (L+3)      . JUMP TO READ NEXT DATA CARD      00071
      AJP 3  (1SAVE)      ENA    (0)        . JUMP IF PERIOD EQUALS ZERO       00072
      STA    (KEY)        SLJ    (L-6)      . RESET KEYBOARD FLAG              00073
      EXF    (2000B)      ENI    (0)        . STOP REAL TIME CLOCK             00074
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        READ 1002, MTIME,NR,MAN,LIMIT,RATE
        EXF    (1000B)      ENI    (0)        . START REAL TIME CLOCK
3TRAK   LDA    (MTIME)      AJP    (1END)     . JUMP IF MANEUVER TABLE TO END
        SUB    (NTIME)      AJP    (4TRAK)    . JUMP IF TIME FOR MANEUVER
        AJP 2  (1WAIT)      ENI    (0)        . JUMP IF NOT TIME FOR MANEUVER
4TRAK   LIL 1  (NR)         LDA 1  (IHEAD)    . SET INDEX ONE TO TRACK NUMBER
        SCL    (MASK4)      SUB    (MOD8)     . UNPACK OLD MANEUVER CODE
        AJP 1  (5TRAK)      ENA    (1)        . JUMP IF OLD TRACK
        SUB    (MAN)        AJP 1  (2TRAK)    . JUMP IF NOT START COMMAND
        LDA 1  (IHEAD)      SCL    (MOD8)     . CLEAR OLD MANEUVER CODE
        AJP    (2TRAK)      STA 1  (IHEAD)    . JUMP IF PREVIOUSLY STARTED
        LDA 1  (IPOSIT1)    STA 1  (IPOSIT)   . START
        LDA 1  (JHEAD1)     STA 1  (JHEAD)    .   NEW
        SLJ    (2TRAK)      ZRO    (0)        .     TRACK
5TRAK   LIL 1  (NR)         LDA 1  (IHEAD)    . UPDATE MANEUVER CODES
        SCL    (MASK2)      SUB    (ISKIP)    . UNPACK ISKIP BIT
        AJP    (2TRAK)      LDA 1  (IHEAD)    . JUMP IF KEYBOARD CONTROLLED
        SCL    (MASK4)      STA    (MODPOS)   . UNPACK OLD MANEUVER CODE
        SUB    (MOD8)       AJP    (2TRAK)    . JUMP IF STANDBY TRACK
        LDA    (MAN)        SUB    (IEIGHT)   . CHECK FOR SCRUB COMMAND
        AJP    (1STOP)      LDA    (MAN)      . JUMP IF TRACK TO BE SCRUBBED
        AJP    (2TRAK)      ENI    (0)        . JUMP IF MAN IS ZERO (ERROR)
6TRAK   LDA    (MAN)        ENI    (0)        . SELECT MANEUVER
        INA    (-1)         AJP    (2TRAK)    .    MAN ERROR
        INA    (-1)         AJP    (L+6)      .    TURN
        INA    (-1)         AJP    (L+8)      .    CLIMB/DIVE
        INA    (-1)         AJP    (L+10)     .    CHANGE SPEED
        INA    (-1)         AJP    (1FADE)    .    FADE
        INA    (-1)         AJP    (2FADE)    .    UNFADE
        SLJ    (2TRAK)      ZRO    (0)        . JUMP IF MAN GT SIX (ERROR)
        ENI 2  (4)          LDA    (MODPOS)   . SEARCH FOR TURN
        EQS 2  (MT1)        SLJ    (L+8)      . JUMP IF TRACK NOT TURNING
        SLJ    (1PACK)      ZRO    (0)        . JUMP IF TRACK ALREADY TURNING
        ENI 2  (4)          LDA    (MODPOS)   . SEARCH FOR CLIMB
        EQS 2  (MC1)        SLJ    (L+5)      . JUMP IF TRACK NOT CLIMBING
        SLJ    (1PACK)      ZRO    (0)        . JUMP IF TRACK ALREADY CLIMBING
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        ENI 2 (4)          LDA   (MODPOS)   . SEARCH FOR ACCELERATION           00141
        EQS 2 (MS1)        SLJ   (L+2)      . JUMP IF TRACK NOT ACCELERATING   00142
        SLJ   (1PACK)      ZRO   (0)        . JUMP IF TRACK ACCELERATING       00143
        LDA   (MAN)        SCL   (MASK7)    . MASK MANEUVER CODE               00144
        ALS   (44)         RAD   (MODPOS)   . ADD NEW MANEUVER CODE            00145
        LDA 1 (IHEAD)      SCL   (MASK6)    . CLEAR OLD MANEUVER CODE          00146
        ADD   (MODPOS)     STA 1 (IHEAD)    . REPLACE MANEUVER CODE            00147
        SLJ   (1PACK)      ZRO   (0)        .                                  00150
1FADE   LDQ 1 (IHEAD)      LDL   (IFADE)    . CHECK FOR FADE                   00151
        AJP 1 (2TRAK)      SLJ   (L+3)      . A-JUMP IF ALREADY FADED          00152
2FADE   LDQ 1 (IHEAD)      LDL   (IFADE)    . CHECK FOR FADE                   00153
        AJP   (2TRAK)      ENI   (0)        . JUMP IF NOT FADED                00154
        LDA 1 (IHEAD)      SST   (FFLAG)    . VALID FADE/UNFADE COMMAND,       00155
        STA 1 (IHEAD)      SLJ   (2TRAK)    .   SET FADE FLAG                  00156
1PACK   LDA   (MAN)        ENI   (0)        . SELECT PACK ROUTINE              00157
        INA   (-2)         AJP   (2PACK)    .    TURN                          00160
        INA   (-1)         AJP   (3PACK)    .    CLIMB/DIVE                    00161
        INA   (-1)         AJP   (4PACK)    .    ACCELERATE                    00162
2PACK   LDA   (RATE)       FMU   (TEN)      . TURN                             00163
        ENI   (0)          SLJ 4 (FIX)      .   CALLED                         00164
        STA   (IRATE)      LDA 1 (IHEAD)    .     FOR,                         00165
        SCL   (MASK8)      STA 1 (IHEAD)    .       PACK                       00166
        LDA   (LIMIT)      SCL   (MASK5)    .         INTO                     00167
        ALS   (24)         RAD 1 (IHEAD)    .           ORDERED COURSE         00170
        LDA   (IRATE)      SCL   (MASK9)    .             AND                  00171
        ALS   (33)         RAD 1 (IHEAD)    .               TURN RATE          00172
        SLJ   (2TRAK)      ZRO   (0)        .                  .               00173
3PACK   LDA   (LIMIT)      MUI   (ISCALE2)  . CLIMB                            00174
        STA   (LIMIT)      ENI   (0)        .   CALLED                         00175
        LDA   (RATE)       FMU   (SCALE2)   .     FOR,                         00176
        FDV   (SIXTY)      SLJ 4 (FIX)      .       PACK                       00177
        STA   (IRATE)      LDA 1 (JHEAD)    .         INTO                     00200
        SCL   (MASK1)      STA 1 (JHEAD)    .           ORDERED ALTITUDE       00201
        LDA   (LIMIT)      SCL   (MASK1)    .             AND                  00202
        ALS   (24)         RAD 1 (JHEAD)    .               CLIMB RATE         00203
        LDA 1 (KHEAD)      SCL   (MASK19)   .                  .               00204
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        STA 1 (KHEAD)     LDA   (IRATE)   .                    .                 00205
        SCL   (MASK16)    ALS   (12)      .                  .                   00206
        RAD 1 (KHEAD)     SLJ   (2TRAK)   .                  .                   00207
4PACK   LDA   (RATE)      SLJ 4 (FIX)     . ACCELERATION                         00210
        STA   (IRATE)     LDA 1 (KHEAD)   .   CALLED FOR,                        00211
        SCL   (MASK20)    STA 1 (KHEAD)   .     PACK                             00212
        LDA   (LIMIT)     SCL   (MASK3)   .       INTO                           00213
        RAD 1 (KHEAD)     LDA   (IRATE)   .         ORDERED SPEED                00214
        SCL   (MASK9)     ALS   (28)      .           AND                        00215
        RAD 1 (KHEAD)     SLJ   (2TRAK)   .             ACCELERATION RATE        00216

* UTILITY SECTION

1WAIT   ENA   (1)         STA   (LEFT)    . STORE                                00217
        LDA   (MTIME)     STA   (MTIMEH)  .   MANEUVER                           00220
        LDA   (LIMIT)     STA   (LIMITH)  .     CARD                             00221
        LDA   (RATE)      STA   (RATEH)   .       DATA FOR                       00222
        LDA   (MAN)       STA   (MANH)    .         MANEUVER                     00223
        LDA   (NR)        STA   (NRH)     .            BEING                     00224
        SLJ   (1MOVE)     ZRO   (0)       .             HELD                     00225
2WAIT   ENA   (0)         STA   (LEFT)    . RESTORE                              00226
        LDA   (MTIMEH)    STA   (MTIME)   .   MANEUVER                           00227
        LDA   (LIMITH)    STA   (LIMIT)   .     CARD                             00230
        LDA   (RATEH)     STA   (RATE)    .       DATA FOR                       00231
        LDA   (MANH)      STA   (MAN)     .         MANEUVER                     00232
        LDA   (NRH)       STA   (NR)      .           BEING                      00233
        SLJ   (3TRAK)     ZRO   (0)       .             HELD                     00234
1END    ENA   (1)         STA   (LAST)    . MANEUVER TABLE EMPTY                 00235
        SLJ   (1MOVE)     ZRO   (0)       .                                      00236
1STOP   LDA   (MOD8)      STA 1 (IHEAD)   . SCRUB TRACK                          00237
        ENA   (0)         STA 1 (IPOSIT)  .                                      00240
        STA 1 (JHEAD)     STA 1 (KHEAD)   .                                      00241
        SLJ   (2TRAK)     ZRO   (0)       .                                      00242
1ERR    LDA   (MOD8)      STA 1 (IHEAD)   . SCRUB TRACK,                         00243
        ENA   (0)         STA 1 (IPOSIT)  .   MOD ERROR, OR                      00244
        STA 1 (JHEAD)     STA 1 (KHEAD)   .     MAX RANGE EXCEEDED               00245
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      SLJ    (4MOVE)      ZRO    (0)        .                                  00246

* UPDATE TRACKS

1MOVE ENI 1 (1)           ENI    (0)        . INITIALIZE TRACK NUMBER INDEX    00247
2MOVE LDA 1 (IHEAD)       SCL    (MASK4)    . UNPACK MANEUVER CODE             00250
      SUB    (MOD8)       AJP    (4MOVE)    . JUMP IF STANDBY TRACK            00251
      ENA    (0)          STA    (TEMP)     . RESET TEMP FADE FLAG             00252
      LDQ 1 (IHEAD)       LDL    (IFADE)    . CHECK FOR FADE                   00253
      AJP    (L+4)        LDA 1 (IPOSIT1)   . JUMP IF NOT FADED                00254
      STA 1 (IPOSIT)      LDA 1 (JHEAD1)    . TRACK PREVIOUSLY FADED,          00255
      STA 1 (JHEAD)       ENA    (1)        .   RESTORE POSITION INFORMATION   00256
      STA    (TEMP)       ENI    (0)        . SET FADED FLAG                   00257
      LDQ 1 (IHEAD)       LDL    (FFLAG)    . CHECK FOR FADE COMMAND           00260
      AJP    (L+6)        LDA    (TEMP)     . JUMP IF NO COMMAND               00261
      AJP    (L+3)        LDA 1 (IHEAD)     . JUMP IF NOT FADED                00262
      SCL    (IFADE)      SCL    (FFLAG)    . UNFADE TRACK,                    00263
      STA 1 (IHEAD)       SLJ    (L+3)      .   RESET FADE BITS                00264
      LDA 1 (IHEAD)       SST    (IFADE)    . FADE TRACK,                      00265
      SCL    (FFLAG)      STA 1 (IHEAD)     .   SET FADE BIT                   00266
      LDA 1 (IHEAD)       SCL    (MASK4)    . UNPACK                           00267
      ARS    (44)         SCL    (MASK7)    .   MANEUVER MODE,                 00270
      STA    (MOD)        LDA 1 (IHEAD)     .     COURSE,                      00271
      SCL    (MASK10)     ARS    (12)       .       SPEED,                     00272
      STA    (ICRS)       LDA 1 (IHEAD)     .         X POSITION               00273
      SCL    (MASK3)      STA    (ISPD)     .           AND                    00274
      LDA 1 (IPOSIT)      SCL    (MASK11)   .             Y POSITION           00275
      ARS    (24)         ENI    (0)        .                .                 00276
      STA    (IX)         LDA 1 (IPOSIT)    .                  .               00277
      SCL    (MASK1)      ALS    (24)       .                    .             00300
      ARS    (24)         STA    (IY)       .                      .           00301
      LDA    (ICRS)       SLJ 4 (FLOAT)     .                .                 00302
      STA    (CRS)        ENI    (0)        .                  .               00303
      LDA    (ISPD)       SLJ 4 (FLOAT)     .                    .             00304
      STA    (SPD)        ENI    (0)        .                      .           00305
      LDA    (IX)         SLJ 4 (FLOAT)     .                .                 00306
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        STA    (X)          ENI    (0)        .                  .                  00307
        LDA    (IY)         SLJ 4  (FLOAT)    .                    .                00310
        STA    (Y)          LDA    (MOD)      .                      .              00311
        AJP 3  (1ERR)       AJP    (1GO)      . SELECT MANEUVER                     00312
        INA    (-1)         AJP    (1ERR)     .    MANEUVER CODE ERROR              00313
        INA    (-1)         AJP    (1TURN)    .    TURN                             00314
        INA    (-1)         AJP    (1DIVE)    .    CLIMB/DIVE                       00315
        INA    (-1)         AJP    (1SPD)     .    ACCELERATION                     00316
        INA    (-1)         AJP    (1CT)      .    CLIMBING TURN                    00317
        INA    (-1)         AJP    (1ST)      .    ACCELERATION IN TURN             00320
        INA    (-1)         AJP    (1SC)      .    ACCELERATION IN CLIMB            00321
        INA    (-1)         AJP    (4MOVE)    .    SCRUBBED TRACK                   00322
        INA    (-1)         AJP    (1SCT)     .    ACCELERATION IN CLIMB-TURN       00323
        SLJ    (1ERR)       ZRO    (0)        .    MANEUVER CODE ERROR              00324

* REPACK SECTION

3MOVE   LDA    (IX)         AJP    (L+4)      . REPACK                              00325
        AJP 3  (L+2)        SUB    (MAX)      .   X POSITION,                       00326
        AJP 3  (L+2)        SLJ    (1ERR)     .     Y POSITION,                     00327
        LAC    (IX)         SLJ    (L-2)      .       COURSE,                       00330
        LDA    (IX)         SCL    (MASK1)    .         SPEED,                      00331
        ALS    (24)         STA 1  (IPOSIT)   .           AND                       00332
        LDA    (IY)         AJP    (L+4)      .             MANEUVER MODE           00333
        AJP 3  (L+2)        SUB    (MAX)      .                .                    00334
        AJP 3  (L+2)        SLJ    (1ERR)     .   IF EITHER                         00335
        LAC    (IY)         SLJ    (L-2)      .     X OR Y IS                       00336
        LDA    (IY)         SCL    (MASK1)    .       GREATER                       00337
        RAD 1  (IPOSIT)     LDA 1  (IHEAD)    .         THAN MAXIMUM                00340
        SCL    (MASK14)     STA 1  (IHEAD)    .           RANGE,                    00341
        LDA    (ICRS)       SCL    (MASK3)    .             SCRUB                   00342
        ALS    (12)         RAD 1  (IHEAD)    .               TRACK                 00343
        LDA    (ISPD)       SCL    (MASK3)    .                  .                  00344
        RAD 1  (IHEAD)      LDA    (MOD)      .                    .                00345
        SCL    (MASK7)      ALS    (44)       .                      .              00346
        RAD 1  (IHEAD)      ENI    (0)        .                                     00347
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       LDQ 1 (IHEAD)      LDL   (IFADE)    . CHECK FOR FADE                    00350
       AJP   (4MOVE)      LDA 1 (IPOSIT)   . JUMP IF NOT FADED                 00351
       STA 1 (IPOSIT1)    LDA 1 (JHEAD)    . TRACK FADED, SAVE                 00352
       STA 1 (JHEAD1)     ENA   (0)        .   POSITION INFORMATION,           00353
       STA 1 (IPOSIT)     STA 1 (JHEAD)    .     SET POSITION TO ZERO          00354
4MOVE  ISK 1 (15)         SLJ   (2MOVE)    . END OF UPDATE LOOP                00355

* EXIT FROM SUBROUTINE

1EXIT  LDA   (NTIME)      STA   (LTIME)    . STORE REAL TIME                   00356
1SAVE  ENI 1 (*)          ENI 2 (*)        . RESTORE INDEX                     00357
2SAVE  ENI 3 (*)          ENI 4 (*)        .   REGISTERS, RETURN               00360
3SAVE  ENI 5 (*)          ENI 6 (*)        .     TO CALLING PROGRAM            00361
       SLJ   (1RET)       ZRO   (0)        . RETURN                            00362

* CONSTANT COURSE SECTION

1GO    LDA   (AXIS)       FSB   (CRS)      . CONVERT COURSE TO POLAR           00363
       FMU   (RADIANS)    STA   (THETA)    .   ANGLE IN RADIANS                00364
       LDA   (SPD)        FMU   (SCALE1)   . COMPUTE SPEED IN                  00365
       FMU   (PERIOD)     FDV   (DEGREES)  .   MILES PER CALLING PERIOD        00366
       STA   (VEL)        ENA   (THETA)    . INCREMENT X                       00367
       SAL   (COSF+1)     SLJ 4 (COSF)     .   .                               00370
       FMU   (VEL)        FAD   (X)        .     .                             00371
       ENI   (0)          SLJ 4 (FIX)      .       .                           00372
       STA   (IX)         ENA   (THETA)    . INCREMENT Y                       00373
       SAL   (SINF+1)     SLJ 4 (SINF)     .   .                               00374
       FMU   (VEL)        FAD   (Y)        .     .                             00375
       ENI   (0)          SLJ 4 (FIX)      .       .                           00376
       STA   (IY)         SLJ   (3MOVE)    .         .                         00377

* TURN SECTION

1TURN  LDA 1 (IHEAD)      SCL   (MASK12)   . UNPACK                            00400
       ARS   (24)         STA   (JCRS)     .   ORDERED COURSE                  00401
       LDA 1 (IHEAD)      SCL   (MASK13)   . UNPACK TURN RATE                  00402
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        ALS   (7)          ARS   (40)        . EXTEND SIGN BIT                  00403
        STA   (IDPS)       LDA   (SPD)       . COMPUTE SPEED                    00404
        FMU   (SCALE1)     FDV   (DEGREES)   .   IN MILES                       00405
        STA   (VEL)        ENI   (0)         .     PER SECOND                   00406
        LDA   (IDPS)       SLJ 4 (FLOAT)     . FLOAT TURN RATE                  00407
        STA   (DPS)        LDA   (JCRS)      . CONVERT ORDERED COURSE           00410
        MUI   (ITEN)       STA   (KCRS)      .   TO TENTHS OF DEGREES           00411
        SUB   (ICRS)       STA   (JUMP)      .                                  00412
        LDA   (IDPS)       AJP 2 (L+3)       . JUMP IF STARBOARD TURN           00413
        LDA   (JUMP)       AJP 3 (1T)        . COMPUTE                          00414
        AJP   (2T)         AJP 2 (L+3)       .   AMOUNT                         00415
        LDA   (JUMP)       AJP 3 (L+2)       .     OF ORDERED                   00416
        AJP   (2T)         AJP 2 (3T)        .       TURN                       00417
        ENA   (JUMP)       SAL   (XABSF+1)   . TURN                             00420
        ENI   (0)          SLJ 4 (XABSF)     .   PASSES                         00421
        STA   (TEMP)       LDA   (NORTH)     .     THROUGH                      00422
        SUB   (TEMP)       STA   (JUMP)      .       NORTH                      00423
        SLJ   (L+5)        ZRO   (0)         .                                  00424
1T      ENA   (JUMP)       SAL   (XABSF+1)   . TURN DOES                        00425
        ENI   (0)          SLJ 4 (XABSF)     .   NOT PASS                       00426
        STA   (JUMP)       SLJ   (L+2)       .     THROUGH NORTH                00427
2T      LDA   (NORTH)      STA   (JUMP)      . 360 DEGREE TURN                  00430
3T      ENA   (IDPS)       SAL   (XABSF+1)   . REMOVE SIGN                      00431
        ENI   (0)          SLJ 4 (XABSF)     .   OF TURN RATE                   00432
        STA   (ICHECK)     MUI   (IPERIOD)   . COMPUTE AMOUNT OF TURN           00433
        STA   (JCHECK)     LDA   (JUMP)      .   POSSIBLE THIS PERIOD           00434
        SUB   (JCHECK)     AJP   (L+2)       . ORDERED TURN = POSSIBLE TURN     00435
        AJP 2 (5T)         ENI   (0)         . ORDERED TURN GT POSSIBLE TURN    00436
        ENQ   (0)          LDA   (JUMP)      . ORDERED TURN LT POSSIBLE TURN    00437
        DVI   (ICHECK)     STA   (ITER)      . DETERMINE NUMBER OF              00440
        LDA   (ITER)       SUB   (IONE)      .   ONE SECOND ITERATIONS          00441
        AJP 3 (4T)         AJP   (4T)        . ONE OR LESS ITERATIONS           00442
        ENI 2 (1)          LDA   (ITER)      . INITIALIZE                       00443
        SAU   (3TURN)      ENI   (0)         .   ITERATION INDEX                00444
2TURN   LDA   (CRS)        FAD   (DPS)       . INCREMENT                        00445
        STA   (CRS)        LDA   (AXIS)      .   X                              00446
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      AJP 2 (L+3)       LDA   (CRS)      . JUMP IF COURSE POSITIVE          00510
      FAD   (DEGREES)   STA   (CRS)      . COURSE NEGATIVE, ADD 360 DEG     00511
      SLJ   (L-3)       ZRO   (0)        . JUMP TO RECHECK                  00512
      LDA   (CRS)       FSB   (DEGREES)  . CHECK FOR COURSE                 00513
      AJP   (L+1)       AJP 3 (L+3)      .   GREATER THAN 360 DEGREES       00514
      LDA   (CRS)       FSB   (DEGREES)  . COURSE GT 360, SUBTRACT 360      00515
      STA   (CRS)       SLJ   (L-3)      . JUMP TO RECHECK                  00516
      LDA   (CRS)       SLJ 4 (FIX)      . CONVERT COURSE                   00517
      STA   (ICRS)      ENA   (0)        .   TO FIXED POINT                 00520
      STA   (NEXT)      SLJ   (3MOVE)    . RESET MULTIPLE MANEUVER FLAG     00521

* CLIMB SECTION

1DIVE LDA 1 (JHEAD)     SCL   (MASK1)    . UNPACK ALTITUDE                  00522
      ALS   (24)        ARS   (24)       . EXTEND SIGN BIT                  00523
      STA   (IZ)        LDA 1 (JHEAD)    . STORE ALTITUDE                   00524
      SCL   (MASK11)    ARS   (24)       . UNPACK                           00525
      STA   (IALT)      LDA 1 (KHEAD)    .   ORDERED ALTITUDE               00526
      SCL   (MASK17)    ARS   (12)       . UNPACK                           00527
      STA   (IFPS)      LDA   (IALT)     .   CLIMB RATE                     00530
      SUB   (IZ)        AJP 2 (L+2)      . JUMP IF CLIMB CALLED FOR         00531
      LAC   (IFPS)      STA   (IFPS)     . DIVE CALLED FOR                  00532
      LDA   (IALT)      SUB   (IZ)       . COMPUTE                          00533
      STA   (TEMP)      ENA   (TEMP)     .   AMOUNT                         00534
      SAL   (XABSF+1)   SLJ 4 (XABSF)    .     OF ORDERED                   00535
      STA   (JUMP)      ENA   (IFPS)     .       CLIMB/DIVE                 00536
      SAL   (XABSF+1)   SLJ 4 (XABSF)    . COMPUTE ABSOLUTE CLIMB RATE      00537
      STA   (JFPS)      MUI   (IPERIOD)  . COMPUTE AMOUNT OF CLIMB          00540
      STA   (TEMP)      LDA   (JUMP)     .   POSSIBLE THIS PERIOD           00541
      SUB   (TEMP)      AJP   (L+2)      . JUMP IF CLIMB = POSSIBLE CLIMB   00542
      AJP 2 (L+4)       ENI   (0)        . JUMP, CLIMB GT POSSIBLE CLIMB    00543
      LDA   (IALT)      STA   (IZ)       . CLIMB COMPLETE,                  00544
      LDA   (MOD)       SUB   (ITHREE)   .   SET ALTITUDE TO                00545
      STA   (MOD)       SLJ   (L+3)      .     ORDERED ALTITUDE             00546
      LDA   (IPERIOD)   MUI   (IFPS)     . INCREMENT                        00547
      ADD   (IZ)        STA   (IZ)       .   ALTITUDE                       00550
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        LDA 1 (JHEAD)     SCL   (MASK11)  . CLEAR AND                          00551
        STA 1 (JHEAD)     LDA   (IZ)      .   REPLACE                          00552
        SCL   (MASK1)     RAD 1 (JHEAD)   .     ALTITUDE                       00553
        LDA   (NEXT)      AJP   (1GO)     . CHECK MULTIPLE MANEUVER FLAG       00554
        SLJ   (1TURN)     ZRO   (0)       . JUMP IF CLIMBING TURN              00555

* SPEED CHANGE SECTION

1SPD    LDA 1 (KHEAD)     SCL   (MASK3)   . UNPACK                            00556
        STA   (IVEL)      LDA 1 (KHEAD)   .   ORDERED SPEED                    00557
        SCL   (MASK18)    ARS   (28)      .     AND                            00560
        STA   (IKPS)      LDA   (IVEL)    .       ACCELERATION RATE            00561
        SUB   (ISPD)      AJP 2 (L+2)     . JUMP IF SPEED INCREASE             00562
        LAC   (IKPS)      STA   (IKPS)    . SPEED DECREASE CALLED FOR          00563
        LDA   (IVEL)      SUB   (ISPD)    . COMPUTE                            00564
        STA   (TEMP)      ENA   (TEMP)    .   AMOUNT                           00565
        SAL   (XABSF+1)   SLJ 4 (XABSF)   .     OF ORDERED                     00566
        STA   (JUMP)      ENA   (IKPS)    .       ACCELERATION AND             00567
        SAL   (XABSF+1)   SLJ 4 (XABSF)   .   MAXIMUM POSSIBLE                 00570
        STA   (KPS)       MUI   (IPERIOD) .     ACCELERATION THIS PERIOD       00571
        STA   (TEMP)      LDA   (JUMP)    .       .                            00572
        SUB   (TEMP)      AJP   (L+2)     . JUMP IF ACCELERATION TO END        00573
        AJP 2 (L+4)       ENI   (0)       . ACCELERATION WILL NOT END          00574
        LDA   (IVEL)      STA   (ISPD)    . ACCELERATION COMPLETE,             00575
        LDA   (MOD)       SUB   (IFOUR)   .   SET SPEED TO                     00576
        STA   (MOD)       SLJ   (L+3)     .     ORDERED SPEED                  00577
        LDA   (IPERIOD)   MUI   (IKPS)    . INCREMENT                          00600
        ADD   (ISPD)      STA   (ISPD)    .   SPEED                            00601
        LDA   (ISPD)      SLJ 4 (FLOAT)   .     .                              00602
        STA   (SPD)       LDA   (NEXT)    . CHECK FOR SPEED                    00603
        AJP   (1GO)       AJP 3 (1DIVE)   .   CHANGE DURING CLIMB              00604
        SUB   (IONE)      AJP   (1TURN)   . CHECK FOR                          00605
        AJP 3 (1TURN)     ENA   (0)       .   TURN DURING CLIMB                00606
        STA   (NEXT)      SLJ   (1DIVE)   . RESET MULTIPLE MANEUVER FLAG       00607
```

```
* MULTIPLE MANEUVER SECTION

1CT    ENA    (1)          STA    (NEXT)     . CLIMBING TURN                    00610
       SLJ    (1DIVE)      ZRO    (0)        .                                  00611
1ST    ENA    (1)          STA    (NEXT)     . SPEED CHANGE IN TURN             00612
       SLJ    (1SPD)       ZRO    (0)        .                                  00613
1SC    ENA    (2)          STA    (NEXT)     . SPEED CHANGE IN CLIMB            00614
       SLJ    (1SPD)       ZRO    (0)        .                                  00615
1SCT   ENA    (-1)         STA    (NEXT)     . SPEED CHANGE IN CLIMBING TURN    00616
       SLJ    (1SPD)       ZRO    (0)        .                                  00617

* KEYBOARD COMMAND SECTION

1KEY   LDA    (IDD65+1)    STA    (NR)       . STORE TRACK NUMBER               00620
       LDA    (IDD65+2)    STA    (KMAN)     . STORE MANEUVER CODE              00621
       LDA    (IDD65+3)    STA    (ICRS)     . STORE COURSE                     00622
       LDA    (IDD65+4)    STA    (ISPD)     . STORE SPEED                      00623
       LDA    (IDD65+5)    STA    (IALT)     . STORE ORDERED ALTITUDE           00624
       LDA    (IDD65+6)    MUI    (ISCALE1)  . SCALE X POSITION                 00625
       STA    (IX)         LDA    (IDD65+7)  . STORE X POSITION                 00626
       MUI    (ISCALE1)    STA    (IY)       . STORE Y POSITION                 00627
       LDA    (IDD65+8)    MUI    (ISCALE2)  . SCALE ALTITUDE POSITION          00630
       STA    (IZ)         LDA    (IDD65+10) . STORE ALTITUDE POSITION          00631
       STA    (RATE)       ENI 2  (1)        . STORE MANEUVER RATE              00632
       ENA    (0)          ENI    (0)        . SET IDD65                        00633
       STA 2  (IDD65)      ENI    (0)        .   ARRAY                          00634
       ISK 2  (12B)        SLJ    (L-1)      .     TO ZERO                      00635
1K     LIL 1  (NR)         ENA    (KMAN)     . SET INDEX ONE TO TRACK NUMBER    00636
       SAL    (XABSF+1)    SLJ 4  (XABSF)    . SET MANEUVER CODE EQUAL TO       00637
       STA    (MAN)        LDA    (IPERIOD)  .   ABSOLUTE VALUE OF KMAN         00640
       AJP 1  (L+2)        ENA    (-1)       . SET                              00641
       STA    (KEY)        SLJ    (L+2)      .   KEYBOARD                       00642
       ENA    (1)          STA    (KEY)      .     FLAG                         00643
       LDA    (MAN)        AJP    (2TRAK)    . JUMP IF MAN ERROR                00644
       SUB    (IEIGHT)     AJP    (1STOP)    . JUMP TO SCRUB TRACK              00645
       LDA 1  (IHEAD)      SCL    (MASK4)    . UNPACK OLD MANEUVER CODE         00646
```

```
        STA    (MODPOS)     SUB    (MOD8)     . SELECT KEYBOARD MANEUVER      00647
        AJP    (6KEY)       LDA    (MAN)      .   START TRACK                 00650
        INA    (-1)         AJP    (2TRAK)    .   ERROR                       00651
        INA    (-1)         AJP    (2KEY)     .   TURN                        00652
        INA    (-1)         AJP    (3KEY)     .   CLIMB/DIVE                  00653
        INA    (-1)         AJP    (4KEY)     .   CHANGE SPEED                00654
        INA    (-1)         AJP    (1FADE)    .   FADE                        00655
        INA    (-1)         AJP    (2FADE)    .   UNFADE                      00656
        SLJ    (2TRAK)      ZRO    (0)        .   ERROR                       00657

* KEYBOARD TURN SECTION

2KEY    LDA    (ICRS)       STA    (LIMIT)    . STORE ORDERED COURSE          00660
        ENA    (RATE)       SAL    (SIGNF+1)  . INSERT PROPER                 00661
        ENA    (KMAN)       SAL    (SIGNF+2)  .   SIGN INTO                   00662
        ENI    (0)          SLJ 4  (SIGNF)    .     TURN RATE                00663
        STA    (RATE)       SLJ    (5KEY)     . END KEYBOARD TURN SECTION     00664

* KEYBOARD CLIMB SECTION

3KEY    LDA    (IALT)       STA    (LIMIT)    . STORE ORDERED ALTITUDE        00665
        SLJ    (5KEY)       ZRO    (0)        .                               00666

* KEYBOARD SPEED CHANGE SECTION

4KEY    LDA    (ISPD)       STA    (LIMIT)    . STORE ORDERED SPEED           00667

* EXIT FROM KEYBOARD ROUTINE

5KEY    LDA 1  (IHEAD)      SST    (ISKIP)    . SET ISKIP                     00670
        STA 1  (IHEAD)      SLJ    (6TRAK)    .   TO ONE                      00671

* START TRACK FROM KEYBOARD

6KEY    LDA    (MAN)        SUB    (IONE)     . CHECK FOR START COMMAND       00672
        AJP 1  (2TRAK)      LDA 1  (IHEAD)    . JUMP IF NOT START (ERROR)     00673
```

```
        SCL    (MOD8)       AJP 1 (2TRAK)    . JUMP IF NOT PREVIOUSLY STARTED   00674
        LDA    (IX)         SCL   (MASK1)    .                                  00675
        ALS    (24)         STA 1 (IPOSIT)   . PACK X POSITION                  00676
        LDA    (IY)         SCL   (MASK1)    .                                  00677
        RAD 1 (IPOSIT)      LDA   (IZ)       . PACK Y POSITION                  00700
        SCL    (MASK1)      STA 1 (JHEAD)    . PACK ALTITUDE                    00701
        LDA    (ICRS)       MUI   (12B)      . CONVERT COURSE TO                00702
        SCL    (MASK3)      ALS   (12)       .   TENTHS OF DEGREES              00703
        STA 1 (IHEAD)       LDA   (ISPD)     . PACK COURSE                      00704
        SCL    (MASK3)      SST   (ISKIP)    . SET SKIP BIT                     00705
        RAD 1 (IHEAD)       SLJ   (2TRAK)    . PACK SPEED                       00706

* DATA PROCESS COMMAND SECTION

7KEY    LDQ    (LHEAD+1)    LDL   (777777B)  . UNPACK MANEUVER RATE             00707
        STA    (TEMP)       LDA   (LHEAD+1)  . STORE MANEUVER RATE             00710
        LRS    (9)          QRS   (39)       . UNPACK Y POSITION               00711
        STQ    (IY)         LRS   (9)        . STORE Y POSITION                00712
        QRS    (39)         STQ   (IX)       . STORE X POSITION                00713
        LRS    (18)         QRS   (30)       . UNPACK MANEUVER LIMIT           00714
        STQ    (LIMIT)      LRS   (4)        . STORE MANEUVER LIMIT            00715
        QRS    (44)         STQ   (NR)       . STORE TRACK NUMBER              00716
        LRS    (5)          QRS   (43)       . UNPACK MANEUVER CODE            00717
        STQ    (KMAN)       LDA   (NR)       . STORE MANEUVER CODE             00720
        SCL    (MASK7)      STA   (NR)       . MASK TRACK NUMBER               00721
        ENI 1 (1)           ENI 2 (1)        . SHIFT                           00722
        INI 2 (1)           LDA 2 (LHEAD)    .   LHEAD                         00723
        STA 1 (LHEAD)       ENI   (0)        .     ARRAY                       00724
        ISK 1 (59)          SLJ   (L-2)      .       UP BY                     00725
        ENA    (0)          STA   (LHEAD+60) .         ONE CELL                00726
        LDA    (KMAN)       INA   (-1)       . SELECT MANEUVER                 00727
        AJP 1 (7K)          LDA   (IX)       . START TRACK                     00730
        MUI    (ISCALE1)    STA   (IX)       . SCALE X POSITION                00731
        LDA    (IY)         MUI   (ISCALE1)  .                                 00732
        STA    (IY)         ENA   (120B)     . SCALE Y POSITION                00733
        MUI    (ISCALE2)    STA   (IZ)       . SET ALTITUDE TO 80 FEET         00734
```

```
        ENA     (170B)      STA     (ISPD)      . SET SPEED TO 120 KNOTS        00735
        LDA     (LIMIT)     STA     (ICRS)      . STORE ORDERED CPURSE          00736
        SLJ     (1K)        ZRO     (0)         .                               00737
7K      INA     (-1)        AJP     (L+3)       .   STARBOARD TURN              00740
        INA     (-1)        AJP     (L+6)       .   CLIMB/DIVE                  00741
        INA     (-1)        AJP     (L+7)       .   CHANGE SPEED               00742
        LDA     (LIMIT)     STA     (ICRS)      .   TURN OR ERROR              00743
        LDA     (TEMP)      SLJ 4   (FLOAT)     . FORM                          00744
        FDV     (10.)       STA     (RATE)      .   MANEUVER RATE              00745
        SLJ     (1K)        ZRO     (0)         .                               00746
        LDA     (LIMIT)     STA     (IALT)      .   CLIMB/DIVE                  00747
        SLJ     (L+2)       ZRO     (0)         .                               00750
        LDA     (LIMIT)     STA     (ISPD)      .   CHANGE SPEED               00751
        LDA     (TEMP)      SLJ 4   (FLOAT)     . FORM MANEUVER RATE            00752
        STA     (RATE)      SLJ     (1K)        .                               00753

        END
```

1. Identification.

Title: PRINT

Category: On Line Display

Programmer: E. L. Borden

Organization: U. S. Naval Postgraduate School

Date: April 1965

2. Purpose.

This subroutine is designed to allow users to display characters and/or vectors on the Data Display model dd 65. The routine enables the user to display data without the trouble of packing special words for the dd 65.

3. Usage.

3.1 Normal Operation.

3.1.1 PRINT provides for entry of the medium size characters. Vectors of any size allowed will be entered by PRINT.

3.1.2 In order to illustrate the usage of PRINT, assume that you wanted to output to the dd 65 the following message:

"NO TRACKS UNDER YOUR CONTROL."

In the memory of the 1604 you would have the following stored:

Address	Contents of cell
22222	4546202351616342
22223	2220244564655120
22224	3046245120634645
22225	2351464373000000

PRO = 1 - right hand tube
0 - left hand tube

ADD = Address in dd 65 memory where message to be stored

X = X position of First Character/Vector

Y = Y position of First Character/Vector

To display the message on the dd 65 the following set of coding is necessary:

```
ENA   (X)              SAL   (PRINT+1)  .
ENA   (Y)              SAL   (PRINT+2)  .
ENA   (PRO)            SAL   (PRINT+3)  .
ENA   (ADD)            SAL   (PRINT+4)  .
ENA   (22222B)         ENQ   (0)        .
SLJ 4 (PRINT)          ZRO   (0)        .
```

The address of the message to be displayed is entered in the Accumulator and the Q-Register is set to zero for character mode or to minus zero for vector mode. If the argument PRINT+4 is deleted the address will be the next available cell in the dd 65 memory.

3.1.3 When the main program executes the subroutine, the subroutine assembles the message and packs it into a designator word and subsequent string words. The packing ends when the end of the message is sensed. To sense the end of the message, PRINT uses two codes. The code 00 is used to sense the end of a character message since this code is illegal. The code 77 is used to sense the end of a vector message since this code is an illegal vector code.

3.1.4 PRINT has a built in sense for end of line and end of page. Before any character or vector is assembled into a word the end of line is sensed. If the end of the line has been reached, the subroutine will reset the X position to an initial position of 400_8 and the Y position will then be checked for end of page. If the end of page has not been reached, the Y position will be decreased by 12_8 and a new designator word will begin with the new X and Y positions. If the end of page is sensed, then the Y

position will be reset to an initial value of 377_8. At this time the new designator word will be formed. The routine also checks to insure that memory is not overflowed. Before packing any word, a memory check is made and if it is found that memory has overflowed, then the memory address is reset to 002_8 and a new designator word is started.

Subroutine PRINT

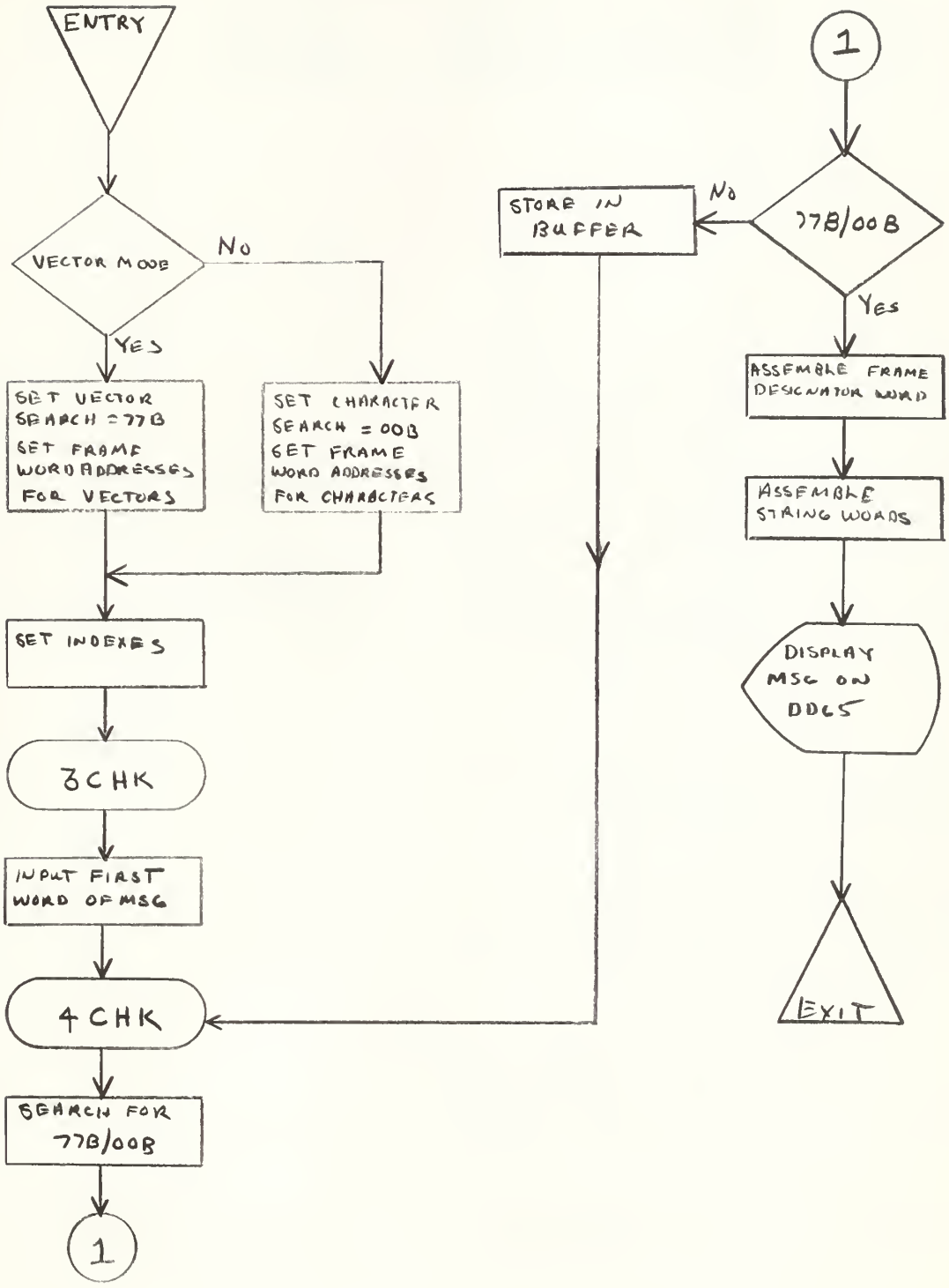

Figure III-1

```
      MACHINE PRINT (1A,2A,3A,4A)

      RSV(BUF=121,OUTPUT=18)

      CON(DW= 3000000000000000B, LTFWC = 1000B, RTFWC = 5000B,V1 = 776B,
     *    LTFWV = 3000B, RTFWV = 7000B, LTSWC = 0B, RTSWC = 4000B,
     *    LTSWV = 2000B, RTSWV = 6000B, XI = -377B, YI = 377B, V = 77B,
     *    MASK1 = 7777777777777000B, DX = 10B, DY=12B)

1RET  SLJ   (N)          SLJ   (1CHK)    . EXIT / ENTRY                          00000
1A    ZRO   (0)          ZRO   (0)       . X-POSITION                            00001
2A    ZRO   (0)          ZRO   (0)       . Y-POSITION                            00002
3A    ZRO   (0)          ZRO   (0)       . 0-LEFT TUBE    1-RT TUBE              00003
4A    ZRO   (0)          ZRO   (0)       . MEMORY ADDRESS                        00004

* SET UP SEARCH WORDS

1CHK  SIU 2 (1SAVE)      SIL 3 (1SAVE)   . SAVE INDEXES                          00005
      SIU 4 (2SAVE)      SIL 5 (2SAVE)   .   2,3,4,5                            00006
      STA   (TEMP)       QJP 3 (2CHK)    . VECTOR OR CHARACTER MODE              00007
      ENA   (LTSWC)      SAU   (5CHK)    . SET SEARCH = ZERO                     00010
      ENA   (LTFWC)      SAL   (1C1)     . SET FIRST WORD                        00011
      ENA   (LTSWC)      SAU   (2C1)     . SET STRING WORD                       00012
      SLJ   (L+4)        ZRO   (0)       .                                       00013
2CHK  ENA   (V)          SAU   (5CHK)    . SET SEARCH = 77B                      00014
      ENA   (LTFWV)      SAL   (1C1)     . SET FIRST WORD                        00015
      ENA   (LTSWV)      SAU   (2C1)     . SET STRING WORD                       00016
      ENI 2 (1)          ENI 3 (7)       . B2 = BUFFER INDEX, B3 = LETTER        00017

* FILL BUFFER SECTION

3CHK  LDQ 7 (TEMP)       ENA   (0)       .                                       00020
4CHK  LLS   (6)          ENI   (0)       .                                       00021
5CHK  EQS   (N)          SLJ   (6CHK)    . SEARCH FOR 00/77                      00022
      SLJ   (7CHK)       ZRO   (0)       .                                       00023
6CHK  STA 2 (BUF)        ENA   (0)       . STORE IN BUFFER                       00024
```

```
       ISK 2 (121)        SLJ   (L+2)     . CHECK FOR FULL BUFFER          00025
       SLJ   (7CHK)       ZRO   (0)       . JUMP IF BUFFER FILLED          00026
       IJP 3 (4CHK)       ENI   (0)       . LOOP FOR 8 CHARACTERS          00027
       RAO   (TEMP)       ENI 3 (7)       . INCREASE WORD ONE ADDRESS      00030
       ENA   (0)          SLJ   (3CHK)    .                                00031
7CHK   INI 2 (-1)         LDA   (4A)      .                                00032

* ASSEMBLY OF DESIGNATOR WORD

       SUB   (V1)         AJP 6 (1MEM)    . CHCEK FOR MEMORY OVERFLOW      00033
8CHK   ENI 4 (18)         LDA   (DW)      . ASSEMBLE FIRST WORD FRAME      00034
       STA 4 (OUTPUT)     LDA 7 (1A)      .                                00035
       STA   (X)          SCL   (MASK1)   .                                00036
       ALS   (36)         RAD 4 (OUTPUT)  . PACK INITIAL X POSITION        00037
       LDA 7 (2A)         STA   (Y)       .                                00040
       SCL   (MASK1)      RAD 4 (OUTPUT)  . PACK INITIAL Y POSITION        00041
       LDA   (4A)         ALS   (13)      .                                00042
       RAD 4 (OUTPUT)     ENI 5 (1)       .                                00043
       SIL 2 (CHECK)      SLJ   (1C)      . SET CHECK                      00044

*RESET MEMORY TO 002 SECTION

1MEM   SLJ   (N)          ENA   (2)       . RESET MEMORY                   00045
       STA   (4A)         SLJ   (1MEM)    .                                00046

* ASSEMBLY OF STRING WORDS

1C     LDA 5 (BUF)        ALS   (30)      .                                00047
       RAD 4 (OUTPUT)     SLJ 4 (1XY)     .                                00050
       INI 5 (1)          LDA 5 (BUF)     .                                00051
       ALS   (24)         RAD 4 (OUTPUT)  . CHECK X-Y POSITION             00052
1C1    INI 5 (1)          ENA   (N)       .                                00053
       ADD   (3A)         STA   (TEMP)    . ASSEMBLE STRING WORD FRAME     00054
       LDA 7 (TEMP)       RAD 4 (OUTPUT)  . PACK MODE, TUBE,AND STRING BIT 00055
       INI 4 (-1)         ENA   (2)       .                                00056
       RAD   (4A)         ENA   (-2B)     .                                00057
```

```
        RAD   (CHECK)      AJP   (1OUT)     . CHECK FOR END OF MSG          00060
        AJP 3 (1OUT)       ENI   (0)        .                               00061
2C      LDA   (4A)         SUB   (V1)       .                               00062
        AJP 6 (1MEM)       ENI   (0)        . CHECK FOR MEMORY OVERFLOW     00063

* FILL STRING WORDS

2C1     ENA   (N)          ENI   (0)        .                               00064
        ADD   (3A)         STA   (TEMP)     .                               00065
        LDA 7 (TEMP)       STA 4 (OUTPUT)   .                               00066
        RSO   (CHECK)      SLJ 4 (1XY)      .                               00067
        LDA 5 (BUF)        ALS   (42)       .                               00070
        RAD 4 (OUTPUT)     INI 5 (1)        . FIRST CHARACTER               00071
        RSO   (CHECK)      SLJ 4 (1XY)      .                               00072
        LDA 5 (BUF)        ALS   (36)       .                               00073
        RAD 4 (OUTPUT)     INI 5 (1)        . SECOND CHARACTER              00074
        RSO   (CHECK)      SLJ 4 (1XY)      .                               00075
        LDA 5 (BUF)        ALS   (30)       .                               00076
        RAD 4 (OUTPUT)     INI 5 (1)        . THIRD CHARACTER               00077
        RSO   (CHECK)      SLJ 4 (1XY)      .                               00100
        LDA 5 (BUF)        ALS   (24)       .                               00101
        RAD 4 (OUTPUT)     INI 5 (1)        . FOURTH CHARACTER              00102
        RSO   (CHECK)      SLJ 4 (1XY)      .                               00103
        LDA 5 (BUF)        ALS   (18)       .                               00104
        RAD 4 (OUTPUT)     INI 5 (1)        . FIFTH CHARACTER               00105
        RSO   (CHECK)      SLJ 4 (1XY)      .                               00106
        LDA 5 (BUF)        ALS   (12)       .                               00107
        RAD 4 (OUTPUT)     INI 5 (1)        . SIXTH CHARACTER               00110
        RSO   (CHECK)      SLJ 4 (1XY)      .                               00111
        LDA 5 (BUF)        RAD 4 (OUTPUT)   . SEVENTH CHARACTER             00112
        INI 5 (1)          IJP 4 (3C)       .                               00113
        SLJ   (1OUT)       ZRO   (0)        .                               00114

* INCREMENT MEMORY ADDRESS

3C      ENA   (2)          RAD   (4A)       .                               00115
```

```
        LDA    (CHECK)      INI 4 (1)        . CHECK FOR END OF MSG          00116
        AJP 3  (1OUT)       AJP   (1OUT)     .                               00117
        INI 4  (-1)         SLJ   (2C)       . LOOP FOR STRING WORDS         00120

* X-Y POSITION CHECK

1XY     SLJ    (N)          LDA   (CHECK)    .                               00121
        AJP 3  (1OUT)       LDA   (DX)       . CHECK FOR END OF MSG          00122
        RAD    (X)          SUB   (377B)     . INCREASE X                    00123
        AJP 2  (L+1)        SLJ   (1XY)      . X OVERFLOW  NO-RETURN         00124
        LDA    (XI)         STA   (X)        .   YES - INCREASE Y            00125
        LAC    (DY)         RAD   (Y)        .                               00126
        ADD    (400B)       AJP 3 (1XY2)     . Y OVERFLOW  JUMP IF YES       00127

* NEW DESIGNATOR WORD SECTION

1XY1    IJP 4  (1X)         SLJ   (1OUT)     .                               00130
1X      LDA    (DW)         ENI   (0)        . ASSEMBLE DESIGNATOR WORD      00131
        STA 4  (OUTPUT)     ENQ   (777B)     .                               00132
        LDL    (X)          ALS   (36)       .                               00133
        RAD 4  (OUTPUT)     LDL   (Y)        . PACK X POSITION               00134
        RAD 4  (OUTPUT)     ENA   (2)        . PACK Y POSITION               00135
        RAD    (4A)         SUB   (V1)       .                               00136
        AJP 6  (1MEM)       LDA   (4A)       . CHECK FOR MEMORY OVERFLOW     00137
        ALS    (13)         RAD 4 (OUTPUT)   . INCREMENT MEMORY ADDRESS      00140
        SLJ    (1C)         ZRO   (0)        .                               00141

* RESET Y TO Y-INITIAL SECTION

1XY2    LDA    (YI)         STA   (Y)        .                               00142
        SLJ    (1XY1)       ZRO   (0)        .                               00143

* OUTPUT TO DD65 SECTION

1OUT    ENI 5  (1)          ENI   (0)        .                               00144
2OUT    LDA 4  (OUTPUT)     STA 5 (OUTPUT)   .                               00145
```

```
        INI 5 (1)          ENI   (0)        .                                  00146
        ISK 4 (18)         SLJ   (2OUT)     . POSITION OUTPUT ARRAY            00147
        INI 5 (-1)         SIL 5 (KT)       .                                  00150
        EXF   (02000B)     EXF   (04001B)   . STOP RT CLOCK  - DISALLOW        00151
        EXF   (77010B)     EXF 7 (77010B)   .                                  00152
        OUT 5 (OUTPUT+1)   ENI   (0)        . OUTPUT TO DD65                   00153
        EXF   (04000B)     EXF   (01000B)   . ALLOW  -  START RT CLOCK         00154
        ENA   (2)          RAD   (4A)       . INCREASE MEMORY ADDRESS          00155
        ENI 5 (121)        ENA   (0)        . ZERO BUFFER                      00156
        STA 5 (BUF)        IJP 5 (L)        .                                  00157
        ENI 5 (18)         ENA   (0)        .                                  00160
        STA 5 (OUTPUT)     IJP 5 (L)        . ZERO OUTPUT BUFFER               00161
1SAVE   ENI 2 (N)          ENI 3 (N)        . RESTORE INDEXES                  00162
2SAVE   ENI 4 (N)          ENI 5 (N)        .                                  00163
        ENA   (0)          STA   (CHECK)    . SET CHECK TO ZERO                00164
        SLJ   (1RET)       ZRO   (0)        . RETURN                           00165

        END
```

APPENDIX IV-A

1. Identification.

Title: COURSE

Category: Course and Velocity determination

Programmer: E. L. Borden

Organization: U. S. Naval Postgraduate School

Date: April 1965

2. Purpose.

This subroutine is designed to take an x-velocity, a y velocity, and a z-position and determines a course in degrees true, a velocity in knots, and a velocity in mach number for any z-position greater than zero.

3. Usage.

3.1 Normal Operation

3.1.1 The normal calling sequence of COURSE is as follows:

VX = X-velocity in knots
VY = Y-velocity in knots
CRS = Course in degrees true
SPD = Speed in knots
MACH = Mach number
Z = Z-position in feet

```
ENA   (VX)          SAL   (COURSE+1) .
ENA   (VY)          SAL   (COURSE+2) .
ENA   (CRS)         SAL   (COURSE+3) .
ENA   (MACH)        SAL   (COURSE+4) .
ENA   (Z)           SAL   (COURSE+5) .
ENA   (SPD)         SAL   (COURSE+6) .
SLJ 4 (COURSE)      ZRO   (0)        .
```

3.1.2 COURSE determines course and speed in the normal manner.

Mach number is determined by the following formula:

$$\text{MACH} = \frac{\text{SPD(knots)}}{661 - 2.5 \times \text{ALT(Kft)}}$$

The above formula is valid for ALT less than 35,000 feet. If ALT is greater than 35,000 feet, it is reduced to 35,000 feet.

Subroutine COURSE Chart 1

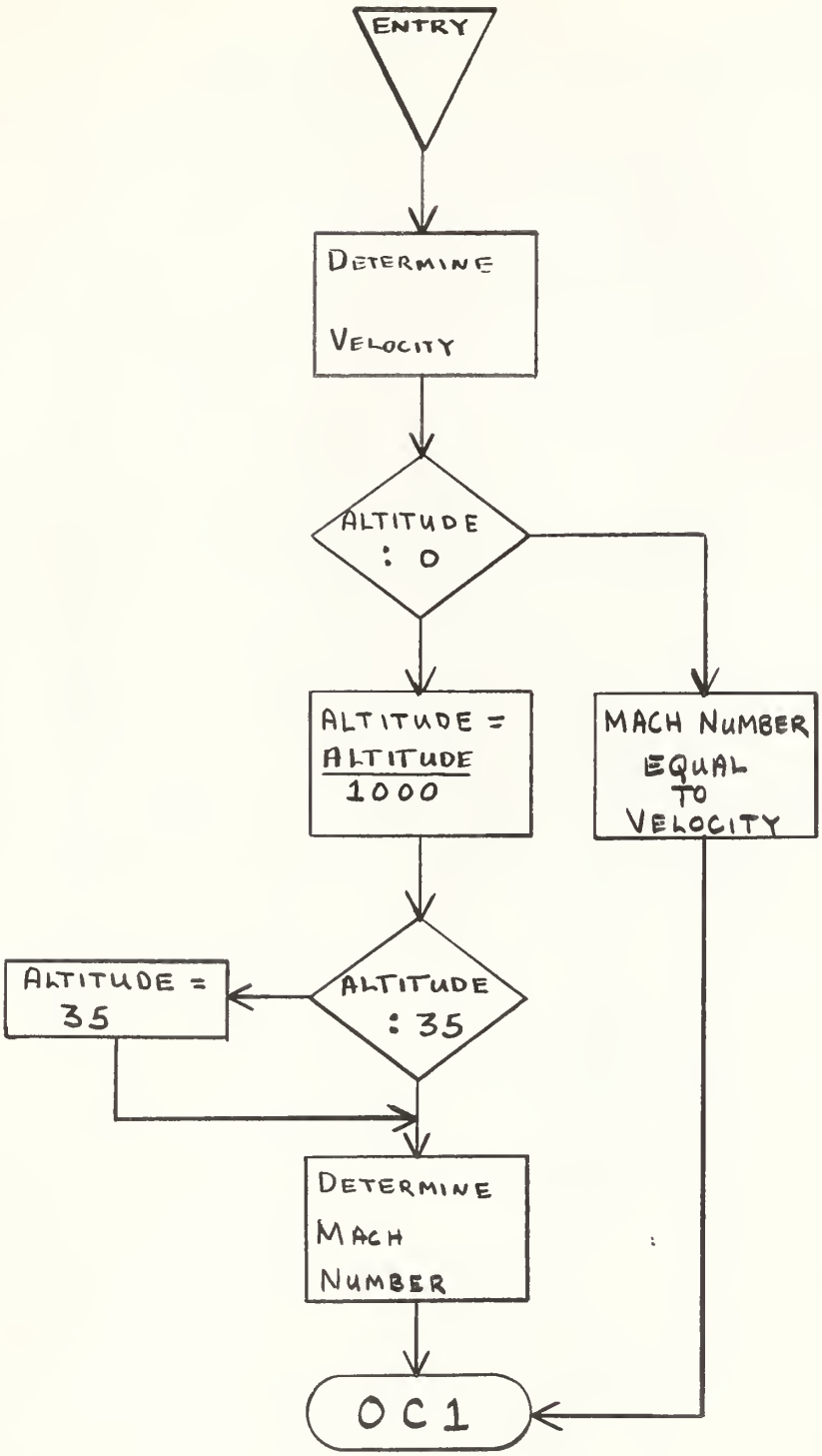

Figure IV-1

Subroutine COURSE Chart 2

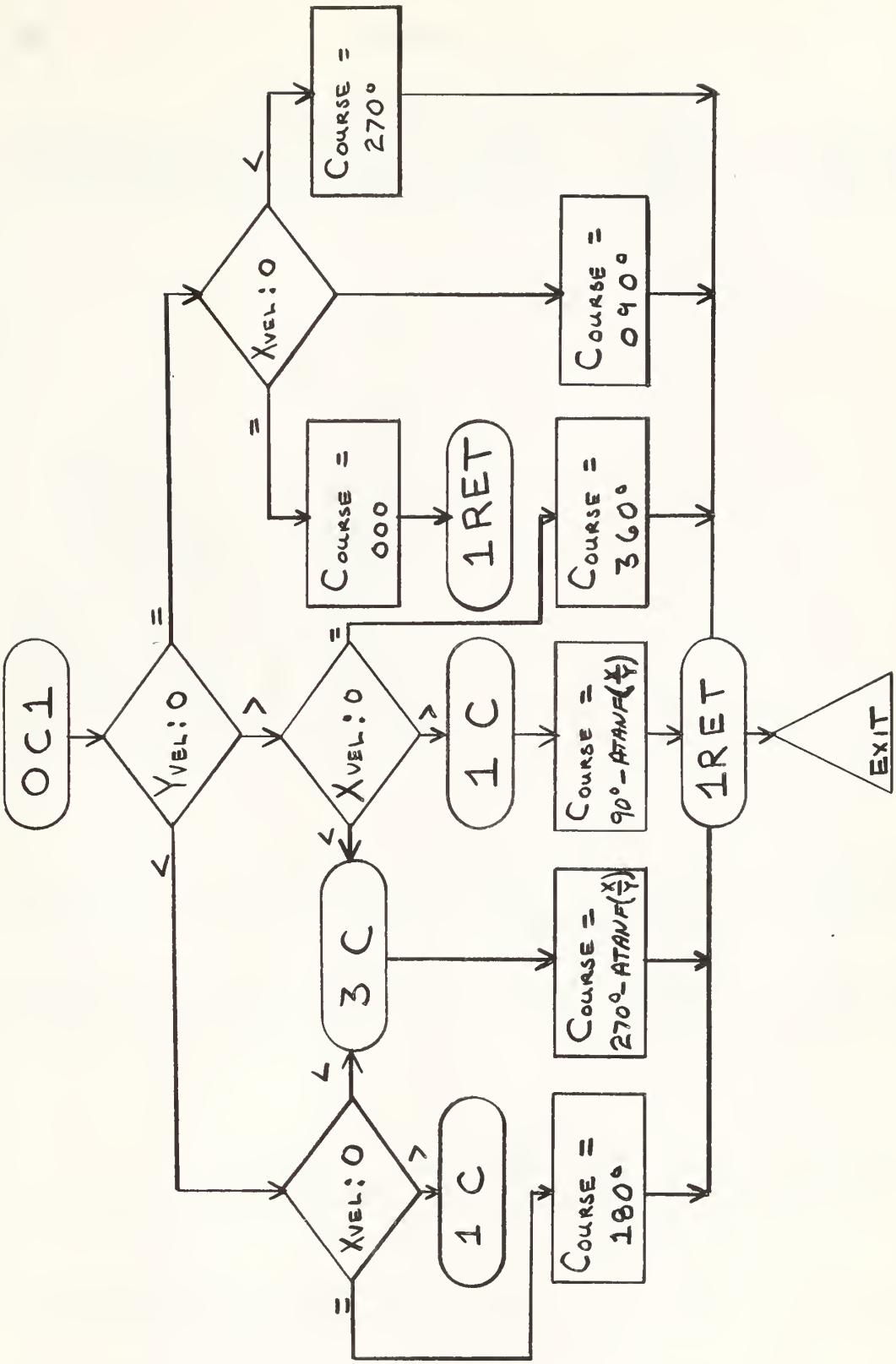

Figure IV-2

```
      MACHINE COURSE(1A,2A,3A,4A,5A,6A)
      LIB(SQRTF=SQ,ATANF=AT)
1RET  SLJ   (N)          SLJ   (L+7)     . EXIT/ENTRY                          00000
1A    ZRO   (0)          ZRO   (0)       . X VELOCITY IN KNOTS                 00001
2A    ZRO   (0)          ZRO   (0)       . Y VELOCITY IN KNOTS                 00002
3A    ZRO   (0)          ZRO   (0)       . COURSE IN DEGREES TRUE              00003
4A    ZRO   (0)          ZRO   (0)       . SPEED IN MACH NUMBER                00004
5A    ZRO   (0)          ZRO   (0)       . ALTITUED IN FEET                    00005
6A    ZRO   (0)          ZRO   (0)       . SPEED IN KNOTS                      00006
      LDA 7 (1A)         FMU 7 (1A)      . SQUARE X VELOCITY                   00007
      STA   (TEMP)       LDA 7 (2A)      .                                     000110
      FMU 7 (2A)         FAD   (TEMP)    . SQUARE Y VELOCITY                   00011
      STA   (TEMP)       ENA   (TEMP)    .                                     00012
      SAL   (SQ+1)       SLJ 4 (SQ)      . DETERMINE VELOCITY                  00013
      STA 7 (6A)         LDA 7 (5A)      . CHECK Z-POSITION                    00014
      AJP   (0C)         AJP 3 (0C)      . JUMP IF Z .EQ. OR .LT. ZERO         00015
      FDV   (1000.)      FSB   (35.)     . DETERMINE MACH NUMBER               00016
      AJP 6 (0C2)        FAD   (35.)     .                                     00017
      FMU   (2.5)        STA   (TEMP1)   .                                     00020
      LDA   (661.)       FSB   (TEMP1)   .                                     00021
      STA   (TEMP1)      LDA 7 (6A)      .                                     00022
      FDV   (TEMP1)      STA 7 (4A)      .                                     00023

* DETERMINE COURSE

0C1   LDA 7 (2A)         AJP   (6C)      .                                     00024
      AJP 3 (4C)         LDA 7 (1A)      .                                     00025
      AJP   (2C)         AJP 3 (3C)      .                                     00026

* 000-090 DEGREES

1C    LDA 7 (2A)         FDV 7 (1A)      .                                     00027
      STA   (TEMP)       ENA   (TEMP)    .                                     00030
      SAL   (AT+1)       SLJ 4 (AT)      .                                     00031
      FMU   (57.3)       STA   (TEMP)    .                                     00032
      LDA   (90.)        FSB   (TEMP)    .                                     00033
```

```
      STA 7 (3A)        SLJ   (1RET)    .                    00034

* 360 DEGREES

2C    LDA   (360.)      STA 7 (3A)      .                    00035
      SLJ   (1RET)      ZRO   (0)       .                    00036

* 180-270 DEGREES

3C    LDA 7 (2A)        FDV 7 (1A)      .                    00037
      STA   (TEMP)      ENA   (TEMP)    .                    00040
      SAL   (AT+1)      SLJ 4 (AT)      .                    00041
      FMU   (57.3)      STA   (TEMP)    .                    00042
      LDA   (270.)      FSB   (TEMP)    .                    00043
      STA 7 (3A)        SLJ   (1RET)    .                    00044

* 090 -180 DEGREES

4C    LDA 7 (1A)        AJP   (5C)      .                    00045
      AJP 3 (3C)        SLJ   (1C)      .                    00046

* 180 DEGREES

5C    LDA   (180.)      STA 7 (3A)      .                    00047
      SLJ   (1RET)      ZRO   (0)       .                    00050

* 270-360 DEGREES

6C    LDA 7 (1A)        AJP   (8C)      .                    00051
      AJP 3 (7C)        LDA   (90.)     .                    00052
      STA 7 (3A)        SLJ   (1RET)    .                    00053

* 270 DEGREES

7C    LDA   (270.)      STA 7 (3A)      .                    00054
      SLJ   (1RET)      ZRO   (0)       .                    00055
```

```
* 000 DEGREES

8C     ENA    (0)          STA 7 (3A)      .                    00056
       SLJ    (1RET)       ZRO   (0)       .                    00057

* SURFACE OR SUBMARINE MACH NUMBER CLEARER

0C     LDA 7 (6A)          STA 7 (4A)      .                    00060
       SLJ    (0C1)        ZRO   (0)       .                    00061

* RESET Z TO 35000 FEET

0C2    SLJ    (N)          LDA   (35.)     .                    00062
       SLJ    (L-1)        ZRO   (0)       .                    00063

       END
```

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